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THE DEVELOPMENT OF THE HEAVY BOMBER

1918 - 1944

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THE DEVELOPMENT OF THE HEAVY BOMBER
1918-1944

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Historical Division
Air University, U.S. Air Force
August, 1951

The Development of the Heavy Bomber 1918 - 1944

FOREWORD

This historical monograph of the development of the heavy bomber covers the period from the United States' participation in World War I to the end of 1944. As necessary background for the Materiel Division's and aircraft manufacturers' accomplishments, the controversy among the Air Corps, the War Department, and the Navy Department over the heavy bomber's procurement and employment is surveyed in some detail.

The materials for this study were prepared during 1943 and 1944 by Mr. Jean H. DuBuque of the AAF Historical Division. Necessarily limited in its treatment of bomber development and modification in 1944, the draft was revised by Mr. Robert F. Gleckner, USAF Historical Division, Air University. Additional data was supplied to survey various stages in the evolution of the very heavy bomber and to provide an introduction to aeronautical engineering advances beyond the experimental (as of 1944) XB-35 and XB-36.

Like other Air Historical Studies, this monograph is subject to revision, and additional and/or corrective information is welcomed.

C O N T E N T S

INTRODUCTION

Aerial bombardment as an organized weapon of offensive warfare was introduced in the final stages of World War I. Since then it has grown from a useful adjunct to land and sea forces to a major, and often decisive, factor in the strategic and tactical campaigns of modern warfare.

In the years following the last war, the novelty and spectacular nature of the bomber created much speculation as to its future potentialities and gave rise to considerable controversy in high military circles regarding its practical application in national defense. There were a few veteran Army airmen who had early envisaged the striking power of the bomber. But their persistent and often unrestrained efforts in the twenties and thirties to champion its cause aroused opposition in an already cautious War Department and contributed to the placement of restrictive policies on the development and procurement of large, multi-engine aircraft.

National aversion to war, the popular conception that air power was represented by quantity of airplanes rather than by quality, and antiquated policies of national defense, also contributed a considerable share toward retarding the development of the heavy bomber. As a consequence, only a few prototypes of the modern heavy bomber were available for experimental study and service testing in the interim between World War I and World War II.

The following study is a review of the various stages in the evolution of the heavy bomber to the end of 1944, including an insight into the controversial issues that arose between the Air Corps, the War Department, and the Navy Department over its development, procurement and employment, and the major problems confronting the Materiel Division in conducting its bombardment development program. As far as practicable, the overall theme has been interwoven with the manifold difficulties that were successively faced and overcome by the Air Corps in fostering the heavy bomber as the basic weapon of American air power.

Chapter I

THE HEAVY BOMBER CONTROVERSY: FIRST STAGE, 1918-1935

It was not until the closing months of the last war that the Allied bomber emerged as an offensive military weapon. In the earlier years of the war, the Franco-British air services had employed their few bombers primarily in retaliation to the "savage and barbarous" German air attacks upon Paris and London.[1] As a whole, joint bombardment missions had been poorly planned and executed. Damage to enemy installations was negligible since both the British and French were prone to bomb a target once or twice and then shift to another target, thus losing the cumulative effect of successive attack.[2]

When America entered the war in 1917, her Air Service leaders soon were convinced of the value of strategic bombing as a decisive means of destroying vital enemy industrial areas. They advocated careful selection of military objectives and advanced the doctrine of massed day bombing. Many factors intervened, however, to delay the application of this theory. Because of the shortage of airplanes and the general organizational confusion, only one American bombardment squadron saw action prior to the Battle of St. Mihiel in late 1918.[3] On 9 October, however, under the leadership of Brig. Gen. William Mitchell 200 bombers escorted by some 110 pursuits and 50 three-place planes attacked and disorganized German army reserves gathered in the rear for a counterattack.[4] This mission, one of the largest of World War I, gave notice to the bomber as an effective offensive weapon. General Staff acknowledgment of this fact,

however, came only with another war.

Divergent views as to the role of the bomber existed among the Allied airmen. The French opposed the indiscriminate use of the bomber in support of the ground forces; the British and Americans argued about the relative merit of day and night bombing—the former championing night raids without specific targets and the latter urging precision day raids on important military installations.

Besides disagreement over bombing policies, the crude and unwieldy airplanes, unpredictable weather, and strong enemy pursuit interception presented thorny problems. Engine and structural failures often caused abandonment of missions before reaching objectives and invariably necessitated forced landings in enemy territory. Unfavorable weather conditions turned back many airborne missions. The vulnerability of the slow bomber to concerted enemy attack was a grave problem, since Allied pursuit escort, even when used, did not have adequate range to offer much protection, and its value was still a controversial question when the war ended.[5]

Postwar Bomber Development: The Air Service emerged from World War I keenly aware of the many problems it faced before effective utilization of the bomber could become a reality. Not the least of these was the limited appropriations allotted by the War Department to bombardment research and experimentation with resulting inadequate laboratory facilities and testing equipment.

Brig. Gen. William Mitchell, Assistant Director of the Air Service, had as early as 1919 antagonized the General Staff and the Navy Department with his persistent pleas for the development of the bombardment airplane

as the basic weapon of national defense. With a military policy devoted to non-aggression, however, high ranking officers of both services had openly deprecated Mitchell's views that in future wars victory would be won by the nation which first obtained and held the mastery of the air.[6] In the following years, although many veteran airmen agreed generally with Mitchell's air power convictions few dared challenge, as he did, the military judgment of the General Staff. He was strongly supported, in one instance, by the former Chief of Air Service, A.E.F., Brig. Gen. B. D. Foulois. Before a congressional hearing on military aeronautics this officer testified:[7]

> The General Staff of the Army is the policy-making body of the Army and, either through lack of vision, lack of practical knowledge, or deliberate intention to subordinate the Air Service needs to the needs of the other combat arms, it has utterly failed to appreciate the full military value of this military weapon and, in my opinion, has utterly failed to accord it its just place in our military family.

Several months later, General Mitchell proposed an experimental contest between the bomber and the battleship in order to dramatize his conviction that air power was superior to seapower for defending the nation.[8] The details of these epochal bombing tests of July 1921 have been recounted many times and need not concern us here. Suffice it to say that although the aerial attack upon the heavily armored warships did demonstrate the effectiveness of the bomber, the policies of the War Department toward developing offensive aircraft restrained for many years the plans of bombardment proponents to build national defense around this airplane.

International agreements of the early twenties lent sanction to the War Department's stand by prohibiting the use of aerial bombing for

terrorizing civilians, destroying private property, or injuring non-combatants.[9] Shortly after the Army bombing exercises in the autumn of 1923, which sank the obsolete battleships Virginia and New Jersey, Col. Dwight F. Davis, Assistant Secretary of War, epitomized this view in characterizing the test as an air assault which reduced a powerful armored battleship to a "helpless ruin of tangled iron and steel by a single bomb." Picturing the damage to life and property which such a bomb would create if dropped upon a crowded city, Davis personally opposed building up a strong offensive air power, particularly in competition with other nations.[10]

In 1926 the frequently intemperate bomber controversy provoked Representative John L. McSwain to charge the General Staff with "intolerance" toward, and "persecution" of, those officers who dared to believe with Generals Mitchell and Patrick, Chief of the Air Corps, that the air force was being "repressed and discouraged." He also stated that officers were being "muzzled" and that every one from the grade of Major General to Second Lieutenant, including reserve officers, were subjected either to expulsion from the Army or to the consequences of an "official frown" for their temerity in disagreeing with the General Staff.[11]

The U. S. Air Force Association followed up Representative McSwain's denunciation with a news release that elaborated on his remarks. J. Edward Cassidy, Director-General of the association, stated that charges frequently made that the General Staff was "an unlimited autocracy" were fully substantiated. He claimed that the General Staff dictated the military policy to the Secretary of War, the President, and to some extent Congress. In addition, the General Staff interfered

with the administrative functions of the various bureaus and was making strenuous efforts to "kill" any bills dealing with aircraft legislation other than those prepared by "swivel-chair officers who know little and care less about the development of the aviation branch of National Defense."[12]

Sporadic attacks of this kind, however, were submerged in the popular cry for economy in government. Following the Air Corps Act of 1926,[13] therefore, only limited funds were allotted by the War Department to the Air Corps delaying fulfillment of its authorized five-year aircraft development program of 1,800 airplanes. And bombers were excluded entirely from the estimate of aircraft procurement for the first fiscal year of 1926-27.

During the late twenties, three major factors—military appropriations (as well as failure of the War Department and the Bureau of the Budget to make appropriated funds available), the national defense policy, and the highly transitional state of aviation—operated most effectively to retard the development of the Army heavy bomber. Maj. Gen. J. E. Fechet, in his first annual report, brought out the necessity of increasing appropriations to the Air Corps to offset the critical shortage of tactical aircraft and the growing loss of flight personnel to commercial aviation.[14]

Despite General Fechet's recommendations, the bombardment strength of the Air Corps continued to decline. In addition to limited funds, the time required to design and develop newer models was a serious handicap: it took from two to five years in peacetime to carry out the various processes from original design to production of service types.

When the bomber finally reached combat units it was already outmoded, since the gradual broadening of tactical doctrines of employment in the interim had stressed more advanced military characteristics.

Faced with this protracted delay in the procurement of much-needed service models, Maj. Hugh J. Knerr, Commanding the 2d Bombardment Group, submitted a request to the Chief of Air Corps in May 1928 for the development of two new types of multi-engine monoplane bombers. Recent employment of existing service bombers in tactical problems had indicated the need for a faster high speed bomber having strong fire power, a small bomb load, and a short range for day operations, and a model having maximum offensive and minimum defensive power with a long range and heavy bomb load for night operations. It was believed that the day bomber would serve to execute a swift mission requiring precision bombing and ability to outrun and outfight enemy pursuit, whereas the slower night bomber, with a heavier bomb load, would perform general bombing and rely upon darkness to help elude attack.[15] Meanwhile, in Army headquarters, the General Staff was urging the standardization of bombardment airplanes and the development of an all-purpose model, presumably to reduce expenditures for research and experimentation. General Fechet, Chief of Air Corps, had referred this matter to the Commanding Officer of the 2d Wing, requesting recommendations from the 2d Bombardment Group and the Air Corps Tactical School.[16] Major Knerr immediately pointed out that it was folly to hamper and restrict bomber design since it would eventually lead to the loss of the Army's most powerful military weapon through incorrect employment.[17]

Lt. Col. C. C. Culver, Commanding the 2d Wing, after reviewing the

reports from Knerr and the Air Corps Tactical School, concurred as to the necessity for "a single purpose airplane rather than one which may be susceptible to modification to adapt it to other uses, thereby making it a mediocre all-purpose airplane rather than a first-class single purpose one."[18]

Despite strong objections from the airmen who were still flying obsolescent service bombers, the Chief of Air Corps ordered the Materiel Division to proceed with the engineering development of the fast, bi-motored airplane adaptable for day and night bombing operation as well as observation missions.[19] The Chief of Materiel Division protested that the specifications for this type of airplane were unsuitable for service operations and for many months considerable correspondence was exchanged on the subject.[20]

Major Knerr waited more than six months for specific action on his recommendations. Finally, he wrote to the Chief of Materiel Division urging that the day bomber type he had earlier proposed be given every possible assistance and priority.[21] Revised specifications for day bomber performance, seconded by both the Bombardment Board and the Air Corps Tactical School, were also proposed in Knerr's letter: a high speed of 160 miles per hour, a bomb load of 1200 pounds, a service ceiling of 18,000 feet, six machine guns, normal radius of action of 250 miles, and an improved bomb carrying device.[22]

Nevertheless, contrary to the requests of these bombardment proponents for a fast day bomber of special design, the Materiel Division, in compliance with final orders from the Chief of Air Corps, developed the Curtiss XO-35 as a twin-engine observation plane, with a modified version--the XO-35A--for fast day bombardment operations.[23]

The Air Corps Tactical School concerned over the growing confusion regarding the designation of bomber types, recommended in March 1930 that two models of bombardment airplanes be adopted--a light model carrying a maximum bomb load of 1200 pounds and a heavy model carrying a minimum bomb load of 2500 pounds. It was tactically incorrect, the School averred, to designate one as a day bomber and the other as a night bomber. While the former would normally be employed by day and the latter by night, circumstances would frequently require a reversal of operation, thus causing misunderstanding as to the true employment of the particular model under existing nomenclature.[24] The Materiel Division supported the views of the School and added that because of the small number of "types of bombardment airplanes which will probably be in use by the Air Corps, no difficulty will be encountered in assigning airplanes to the two classes of bombardment operation."[25]

Thus, in 1930, the future development of the heavy bomber was at best unpredictable. Its proponents, apparently undismayed by the adverse turn of events, continued to plan and recommend design changes, striving to attain two main objectives for later types--long range at high altitude with maximum bomb load and precision bombing equipment for both high and low altitude operations.

In 1931, the Air Corps 5-year aircraft procurement program terminated. Although the Act of 1926 had authorized 1800 airplanes, there existed a shortage of 300 or more, and of the total number procured, only 39 were of the bombardment type.[26] Many of those were unsuitable for tactical use, because of age and improper type distribution. The Baker Board Report stated that the program was initially delayed and subjected to continuous interference and postponement by the failure of Congress to

appropriate all funds requested by the War Department.[27] This allegation, however, did not agree with Air Corps budgetary and fiscal records. Over the five year period, the appropriations made by Congress, in most cases exceeded that approved by the Bureau of the Budget; drastic reductions in estimated funds requested by the Air Corps were made by the Secretary of War. The total funds requested by the Air Corps for the five year program had amounted to $182,759,059 but the Secretary of War only approved a total of $126,136,476, leaving a difference of $56,622,583.[28]

War Department Vision and Revision: When in December, 1931, the Chief of Air Corps requested all bombardment commanders to study their organizations, tactics, aircraft and equipment and to recommend any changes that would help in developing more efficient operation and closer teamwork with all branches of the Army,[29] it was thought that the War Department attitude toward bombardment aviation was undergoing definite change. Pursuant to Colonel Andrews' memorandum considerable advancement was made during the next two years in bomber design, and new doctrines of employment were formulated and tested by bombardment units in a concerted effort to improve precision bombing methods. Meanwhile, however, Great Britain was exerting strong pressure at the Geneva Conference of 1933, to have aerial bombing abolished from warfare under international law.[30] The bomber was to be "outlawed" along with chemical, incendiary, and bacterial weapons. Fortunately for bombardment proponents the dual nature of aircraft resulted in the issue's remaining highly controversial. No logical way could be advanced for limiting the size, range, and weight-carrying capacity of combat aircraft without also jeopardizing the future development of international civil aviation.[31] Finally, while the session

was still in progress the German delegation withdrew claiming that a deadlock had been reached in the international negotiations.[32]

In view of the growing uncertainty in the international situation, the Drum Board convened in August 1933 to review and revise air plans for National Defense. Its membership was composed of general officers of the line, the General Staff and the Chief of Air Corps and the findings of the Board were unanimously adopted and later approved by Secretary of War George H. Dern. In the report, the possibility of the United States' being attacked by "enemy" air forces was discredited. The establishment of a General Headquarters Air Force of 1800 planes was proposed, however, to be employed strategically for long-range reconnaissance, for interdicting enemy reconnaissance and movements, and for offensive action against important enemy installations. Tactically, this organization was to support the ground forces in preparation for battle by engaging the enemy air forces in combat. The concept that bombardment aviation, acting independently, could control the sea lanes, or defend the coasts, or produce decisive results in any general mission contemplated under the national defense policy, was labeled as "visionary".[33] In 1934, Secretary Dern lent force to this report by denouncing the destruction of armies or populations by bombardment as the "phantasy of a dreamer." An invader of the United States would be unwilling "to waste efforts in meaningless aerial bombardment." Further, he believed that the procurement of great numbers of airplanes would never protect the American people from a determined foe: the best protection was to accept and build upon American tradition and not to "purchase freedom with gadgets."

The moot question of General Staff control over the Air Corps was discussed by the Secretary, who declared that because this body would not accede to every Air Corps demand, it had been accused of repressing aviation development. Like other Army agencies, the Air Corps "fretted" under the restrictions of unified direction and to surrender to its every behest would, he believed, demonstrate a "willingness to discount the best teachings of history."[34]

In general, the opinions voiced by Dern were echoed by the majority of officers on the General Staff, who could not envisage the need for a strong air arm, especially with the heavy bomber as the basic offensive weapon. The Navy Department, in particular, criticized the Army Air Corps for its efforts to develop and employ bombardment aviation for coastal patrol.* Since the Navy was traditionally the "first line of defense" any Army air activities ranging beyond the sea lanes was considered an infringement upon their long-accepted prerogative of protecting the coastline and overseas possessions.[35]

In view of the general deprecation in high military circles of the value of heavy bombardment in defending the nation, the statement made by General Douglas MacArthur, Chief of Staff, in June 1934, was especially liberal. He declared that the bombardment airplane was the most important element of the GHQ Air Force. In addition, it furnished the greatest striking power and made it possible to inflict damage on an enemy in the rear areas of his armies and his zone of interior, which no other weapon could do.[36] When the Baker Board convened a month later, however,

* See Appendix A for a full discussion of this controversy.

it fully concurred in the statements made earlier by Secretary of War Dern. The Board had been called by the War Department to study future aircraft requirements for the Air Corps, and in consonance with its predecessor, the Drum Board, the possibility of an air attack upon the United States was strongly decried. Furthermore, it was contended that no nation could possibly maintain sufficient bombardment aircraft to conduct heavy raids upon American cities, even if aircraft were available, capable of crossing the Atlantic or Pacific with full military load, attacking, and returning to their base.[37]

Thus, in the summer of 1934, the views of bombardment proponents that the nation primarily needed for its security a large mobile force of land-based heavy bombers, were described by the Baker Board as the "conceptions of those who fail adequately to consider the effect of ocean barriers and other limitations." Yet, it was the very impregnability of these natural barriers that the Air Corps challenged, since aircraft, particularly bombers, were increasing in speed, altitude, and range. Reluctance on the part of the War Department, however, to appropriate additional funds for broad experimental bombardment aircraft development plus the strong Navy Department effort to assume control of all land-based bombardment operations definitely retarded Air Corps efforts to promote general acceptance of its heavy bomber program.

Despite all hampering influences, the Materiel Division had underway (since July 1933) a preliminary study for the development of ar experimental four-engine monoplane bomber of radical design to solve the problem of "maximum range" with "a 2,000 pound bomb load." Favorable results from Wright Field prompted the Air Corps to submit its "Project A" to build

such a plane to the War Department. The plan was approved "in principle" by the General Staff and by June 1934 preliminary contracts authorized by the Chief of Staff were completed with the Boeing Aircraft Company. The XB-15, as the projected plane was designated, was not completed until 1937 (and then it was aerodynamically a failure), but Project A eventually gave birth to famous progeny--the B-17, the B-24, and the B-29.

Chapter II

THE HEAVY BOMBER CONTROVERSY: SECOND STAGE, 1935-1939

In July 1935, shortly before the new Army four-engine monoplane bomber, the Boeing XB-17, made its successful maiden flight, Brig. Gen. Oscar Westover, Assistant Chief of Air Corps, outlined to the War Department his concept of future bombardment development. Citing the XB-17 and the Martin B-10 as examples of the long range and short range bomber, Westover believed that although the former was approximately 75 per cent higher in cost the total striking power of the heavy bomber was far more important than mere numbers of aircraft. Assuming that the performance of the XB-17 would greatly exceed that of the B-10, it was considered that from the standpoint of personnel, operation, and maintenance the heavier type would be more economical for service procurement. From the strategic viewpoint, the advantage also rested with the larger, long-range bomber since in a national emergency Hawaii, Alaska, or Panama could be reinforced with little initial preparation. As bombers increased in size and range, it was believed that the older models could be reclassified as medium types and employed for long range reconnaissance, thus obviating the necessity for building special models for this purpose.[1]

So impressive was the maiden flight of the XB-17 at Seattle on 28 July 1935, and subsequent performance tests conducted by the Materiel Division at Wright Field, (in August 1935 it flew nonstop at an average speed of 232 miles per hour from Seattle to Dayton, a distance of 2100 miles) that

the Air Corps recommended purchase of sixty-five models in place of one hundred and eighty-five other aircraft previously authorized for the fiscal year 1936.[2] Before a formal evaluation board could meet however, the original XB-17 was destroyed in a crash, 30 October 1935, and although official investigations cleared the bomber of mechanical and structural failure, the original request for sixty-five was reduced to thirteen by the War Department.[3] Ultimately, only three XB-17's were specifically ordered for service test and it wasn't until August 1937, in fulfillment of a contract closed 17 February 1936, that all 13 had been delivered.[4]

Meanwhile, the Materiel Division was conducting research (begun in 1933) and experimentation in order to develop an ultra long range bomber along the lines earlier mentioned by General Westover. Two light bombers were cut from the budget estimates for 1937 to provide necessary funds for the experimental construction of one XB-15 (Project A) four-engine model. When the revised budget reached the Office of Secretary of War Harry H. Woodring, however, this item was deleted and the funds reallocated for the procurement of spare engines and parts.[5] This unfavorable action by the War Department signified to Air Corps heavy bomber proponents that their efforts to increase the long range offensive power of these airplanes would be beset with difficulties, delays, and drastic reductions of estimated needs.

General Westover apparently had early recognized the possible trend of events, for in November 1935 he informed all Air Corps Stations that Chief of Staff General Malin Craig had advanced the opinion that the Air Corps had suffered in the past because of failure to understand its many and varied problems in relation to other branches of the Army. As a result,

delays had occurred in the completion of approved aircraft programs. In addition he asserted that there had been many instances of too aggressive and enthusiastic effort by certain Air Corps officers in seeking remedial measures for aviation problems. Their methods had been contrary to official procedure and thus had failed to attain the desired results. Although higher authority desired to establish the Air Corps on an effective basis, officers were advised to accept any unfavorable decisions, avoid open criticism, and refrain from making recommendations without careful deliberation of the facts in the case. All future controversial opinions on service programs were to be submitted through appropriate military channels.[6]

Four-Engine Bomber Procurement Restricted: Despite strong protests from high ranking officers of the Air Corps and GHQ Air Force during the late thirties, the War Department reduced, substituted for, or eliminated entirely, the estimated needs for needs for heavy bombers. In brief, the critical situation confronting the heavy bomber proponents is exemplified by the fact that although two hundred and six B-17's and eleven XB-15's were requested in Air Corps estimates from October 1935 through 30 June 1939, only 14 four-engine airplanes were delivered to GHQ Air Force bombardment units up to the outbreak of the European war--thirteen B-17's and one XB-15.[7] Inability to obtain these heavy bombers delayed the normal expansion of the GHQ Air Force into a strong offensive organization for national defense, and resulted in a cross-fire of arguments between the Commanding General and the War Department with the Chief of Air Corps literally acting as a mediator.

A serious blow was delivered in June 1936 to the proposed procurement of four-engine bombers for reinforcement of garrisons in Hawaii, Alaska,

and Panama. The General Staff, in studying aircraft procurement for the Air Corps in FY 1938, rejected the request for eleven B-15's and fifty B-17's, declaring that no tactical or strategic requirement existed for a service bomber with a 3500 mile range. The Chief of Air Corps was advised that until the international situation indicated a need for this type of bomber no more would be procured except for experimental purposes. Preference would be given to the purchase of the medium range B-18 bomber which fulfilled all reasonable military requirements and could be justified from the standpoint of initial cost, maintenance expense, and operating facilities. As a future policy, the Chief of Air Corps was also directed to concentrate his efforts and available funds for acquiring aircraft of reasonable performance, rather than have nothing as a result of reaching for the ideal.[8]

Shortly afterward, Brig. Gen. H. H. Arnold, Assistant Chief of Air Corps, protested the reduction in four-engine bomber estimates for the fiscal years of 1937-38, and recommended adjustment of the War Department economy policy toward bombardment aircraft procurement in order to supply the requested number of these airplanes.[9] During this same month, September, the War Department conceded authority to the Chief of Air Corps to proceed with proposed plans for the experimental development of a Project D (XB-19) four-engine, ultra long range bomber. In this connection, permission was granted to exercise an option with the Douglas Aircraft Company which had been pending since October 1935, and one model was to be constructed chiefly to provide engineering data on very large airplanes. There followed, however, a pointed reminder that the action taken did not indicate a fundamental policy change on the part of the War Department toward long range bombardment aircraft.[10]

Although the War Department had made some concessions during 1936 toward the development of superior heavy bombers, the situation still remained critical at the close of the year. Lt. Col. G. E. Brower, Assistant Chief of Supply Division, informed General Arnold in December of the many problems facing the Air Corps in procuring four-engine bombers. If the War Department failed to authorize further purchase of these airplanes, aircraft manufacturers who had been encouraged to invest large sums of money in experimental development would be confronted with serious difficulties. There were two such manufacturers--Boeing and Douglas--who were greatly concerned over the lack of planning and integrity of intention in the War Department. In the case of unforseen exigencies, such as reduction of appropriations and engineering and procurement problems, delays were understandable, but arbitrary changes without cogent reasons, when large private expenditures were at stake, would threaten the whole future of the aircraft industry.[11]

Shortly thereafter, the Chief of Air Corps reopened the heavy bomber issue with the Chief of Staff, urging that twenty B-17's be added to the 1938 budget estimate. The three models to be delivered in several weeks would permit completion of performance tests in time to include these additional airplanes in the procurement program. (Contracts, of course, were dependent upon the final results of the tests.) This recommendation, however, was disapproved by Secretary of War Woodring.[12]

Much pressure was exerted in the early months of 1937 to purchase the ten undelivered B-17's contracted for in 1936. Air officers believed that accelerated service employment would impress those in high authority with the fact that this bomber possessed the superior military characteristics needed to bolster national defense. The three YB-17's that were delivered

in January-February had completed exhaustive performance tests and were labeled by the GHQ Air Force personnel as the "best bombardment aircraft in existence."[13] Nevertheless, the Boeing option was still pending in the summer of that year. In an effort to stir action, Maj. Gen. Frank M. Andrews, Commanding the GHQ Air Force, strongly urged the War Department to limit all future bombardment aircraft procurement to the four-engine type since a large number of twin-engine models were already under contract.[14]

In answer to General Andrews' memorandum General Arnold pointed out that the basic problem requiring clarification was the role and employment of the GHQ Air Force.[15] Some confusion existed at that time as to whether the Air Corps or the Naval Air Service should provide bombardment aircraft for National defense. It was the opinion of the General Staff as well as the Navy Department that the Air Corps should concentrate on the development of combat aviation that would give close support to the ground forces, leaving the long-range defense against air attack to naval aviation.* Arnold stressed the necessity of settling this point since it had direct bearing upon the future procurement of four-engine bombers. And he also restated his objection to the substitution of twin-engine bombers for four-engine models.[16]

Symptomatic of the confusion existing among the General Staff as to the function of the GHQ Air Force and the relatives merits of twin-engine, and four-engine bombers is the discussion Col. H. H. C. Richards, Chief, Information Division, had with various staff officers. He found that they were inclined to favor the procurement of the B-18 over the B-17, since twice as many of the former could be purchased for approximately

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* See Appendix A.

the same amount of money. They also believed that this type had superior flexibility of action and would be less costly to replace in case of an accident. In addition several other reasons had unfavorably influenced General Staff opinion toward the B-17. One was the fear of serious public reaction if a large bomber "cracked up". Another concerned a definite promise made by the Secretary of War to provide a certain number of airplanes; authorizing purchase of the more expensive B-17's would result in falling short of the goal. Consequently, the future procurement of the heavy bomber was hanging in the balance and it seemed that little could be done to remedy the situation. Richards indicated that various legal and production complications were also contributing to the delay in procuring B-17's and was of the opinion that wide publicity was not important at the time. If the B-17 could have had a "ballyhoo" campaign while the "argument between the Chief of Air Corps and the Staff" was underway conditions might have been different. He believed it was advisable to hold off until just before the next Army Appropriation Act, since the Air Corps was temporarily "licked" in its B-17 procurement program.[17]

The question of purchasing the ten B-17's again arose when the Adjutant General informed Secretary of War Woodring that the award for these airplanes and an option to procure five additional models--two to be delivered in spare parts--was in conformity with approved military requirements.[18] After many months of delay it finally appeared that definite action was to be taken to order these long-awaited bombers for the GHQ Air Force.

General Andrews informed the War Department in September 1937 of GHQ Air Force planning for future development and employment of heavy bombardment aircraft. If his command were to perform its rightful role in national defense, it was becoming increasingly important that the War Department

thoroughly consider the rapid progress being made in aircraft and engines. Since the heavy bomber was considered the prime weapon of airpower, first priority should be given to its procurement in the FY 1939-44 program. The requirements of the GHQ Air Force were based upon sound bombardment experience, which had been discussed in four earlier appeals by the Commanding General. The major points presented by the general were as follows: (1) that the heavy load, long endurance, multi-engine bomber should be considered only as a powerful instrument of defense; and, in view of the nation's fortunate strategic position and its defensive policy, such airplanes, as the basic element of the GHQ Air Force, were essential to the accomplishment of its mission; (2) that such an airplane, with bomb and fuel loads interchangeable to a high degree, offered the most economical and efficient means of performing the functions of reconnaissance and bombardment--although not on the same mission; (3) that per ton of bomb load and per square mile of area reconnoitered, an airplane of the type considered was actually cheaper to operate than small medium bombers, such as the B-10 or B-18 type; (4) in view of the above factors, the process of aircraft and engine experimental development had to continue so that bombers of longer range and superior performance could be made available.[19]

General Arnold, in commenting later on Andrews' recommendation, advised the War Department that an Air Corps Technical Sub-Committee had been designated to review and recommend new military requirements for bombardment type airplanes to be procured in the 1939 program. This sub-committee was composed of representatives from the Supply Division of the General Staff, the GHQ Air Force, the Air Corps Materiel Division, and the Office of the Chief of Air Corps. A meeting had already been held in September

of that year and another was scheduled for 1 November. Andrews' letter was to be considered by the Committee and a report prepared for the Chief of Air Corps for appropriate action.[20]

While the heavy bomber procurement issue was shifting back and forth, the Air Corps Tactical School had completed a study of the War College text Air Force and War and had found it contrary to established Air Corps doctrines and School policies and regulations. In its treatment of bombardment aviation, for example, the text emphasized the "general ineffectiveness" of this arm. One hypothetical case was cited as evidence: "Hence to completely isolate all of the 51 largest cities in the U. S. would require from 495,000 to 918,000 indirect airplane attacks."[21]

Apparently the War Department concurred in this judgement by the War College for the Air Corps was forewarned not to request additional four-engine bombers in its program for 1939 but to submit estimates for "2-engine planes exclusively."[22] When the Air Corps accordingly submitted its budget, even the conservative number of medium bombers designated was drastically reduced.

Experimental Bomber Development Delayed: Despite the continued objection of the War Department to heavy bombardment airplanes, General Westover in late 1937 submitted a list of the principal characteristics desired in an advanced long-range, high altitude bomber and requested the approval of Secretary Woodring. Performance specifications included a minimum high speed of 240 miles per hour at 15,000 feet, a 25,000 foot service ceiling, an operating range of 2600 miles, increased armament, and a bomb load in excess of 2000 pounds. The mission to be performed

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was described as "long range reconnaissance and the destruction by bombs of land or naval materiel objectives."[23] Shortly afterward, Woodring, apparently in compliance with the request of the Chief of Air Corps, circularized twelve aircraft manufacturers with the required military characteristics for an advanced experimental bomber. A short informal design competition for the purpose of surveying all possibilities of this type was scheduled for an early date. This was to be followed by the usual formal open competition, with submission of experimental models and bids about one and a half years after issuance of circular proposals, tentatively set for May 1938.[24]

Considerable interest was being manifested in early 1938 by Air Corps and GHQ Air Force officers in the pressure cabin operation of the Lockheed XC-35, a twin-engine, low wing commercial monoplane (Electra) which was then undergoing Army performance tests. Many were visualizing the possible application of the pressure cabin principle to bombardment aircraft. Col. Frank D. Lackland, Acting Chief of Materiel Division, suggested to the Chief of Air Corps in February that the time appeared right for applying the experience gained in over 100 hours of testing the XC-35 to the construction of an experimental substratosphere bomber. There were at least four aircraft manufacturers possessing facilities for building such an airplane, in which, they were convinced, a pressure of 8000 feet could be maintained at 35,000 feet for efficient crew operation. The estimated cost of this project would be approximately $2,000,000. It was recommended that a portion of the 1938 funds be made available to contract for one model, with the balance becoming payable the following year. Action was urged by Lackland before 1 July, 1938.[25] General Westover, however,

was of the opinion that it was impractical to execute Lackland's plans in view of the limited time before the end of the fiscal year. Therefore he requested that the existing plan for the development of pressure cabin aircraft be continued until further notice.[26]

Brig. Gen. A. W. Robins, however, immediately came to the support of his assistant and recommended that the Chief of Air Corps obtain from the Office of the Secretary of War permission to proceed with the proposed experimental pressure cabin bomber as a secret project.[27] General Arnold who was also interested in the substratosphere bomber, was arranging in March 1938 to convene an Aviation Board at Wright Field, composed of representatives from the Air Corps Wings, the GHQ Air Force, the Materiel Division, and his office. The Board was to evaluate all existing data on four-engine bombers and recommend the military characteristics required for the development of more advanced, long range, high altitude types. When General Andrews wired the office of the Chief of Air Corps that his special representative, Lt. Col. Joseph T. McNarney, could not attend because of the forthcoming GHQ Air Force maneuvers, General Arnold expressed the opinion that the conference on bombers was "important enough to warrant the best brains GHQ has." In fact, he considered it more important than the maneuvers.[28] General Andrews later expressed to General Westover his own growing concern over the delay in developing a large, ultra long range bomber of the 250,000 pound class. Until world stabilization of aircraft size was an actuality, he felt that the Materiel Division should continue to study mammoth airplane design, utilizing all available funds, engineering skill, and materiel in the production of an experimental model. The application of the pressure cabin principle to an airplane of this size was an accomplished fact, although there still

remained certain problems to solve, such as the development of sealed gun apertures, sealed bomb bays, double pressure doors, and other special equipment.

Meanwhile, the controversial issue of four-engine bomber procurement between the Air Corps and War Department was still unresolved. The Chief of Air Corps had been reinformed that, in accordance with the directive of the Secretary of War, only twin-engine models would be procured for 1939.[29]

General Arnold, nevertheless, continued to champion the procurement of the experiemntal substratosphere bomber. He recommended to the Secretary of War, a few days after the above-mentioned memorandum that a contract for government-furnished equipment be made in 1938 from Project A funds and suggested that payments for partial completion of the project be deducted from 1939 allocations with option to pay the balance in the ensuing fiscal year.[30]

It is noteworthy that in June 1938, motivated perhaps by the show of German, Italian and Russian air power in the Spanish Civil War, the War Department changed somewhat its restrictive policy toward four-engine bomber procurement. Substitution of eleven B-17's for thirty-two B-18's was authorized for the 1939 program by the Secretary of War.[31] Several days before this authorization, the Chief of Air Corps had requested that the 1938 aircraft estimate be amended to include one YB-20 (modified XB-15) for service test instead of procuring two similar models of the XB-15.[32] But the Secretary of War had made one concession; the YB-20 recommendation was rejected. Arnold was informed that all non-obligated funds previously allocated for 1938 purchase of two XB-15's would be applied to procuring the twin-engine bombers already approved for that year.[33]

It was during this year, that various foreign nations were stepping up the experimental development and testing of large, four-engine high speed bombers. Some of their models had surpassed in size and performance the B-17. Taking advantage of this situation General Andrews once again in June, advanced many reasons to keep alive the projected development of the substratusphere bomber. He stressed the fact that such an airplane represented at least five years of continued development before it could be "expected to fly experimentally".[34] He emphasized strongly foreign progress in four-engine bomber development and advocated patrolling the South Atlantic, Alaska and the Philippines with ultra long range bombers, since the international situation justified maintaining the GHQ Air Force "in peace on a wartime basis."[35] General Westover, however, refused at that time to support Generals Andrews and Arnold in promoting the substratosphere bomber, apparently because of the existing policy of the War Department.[36]

General Andrews again in June stressed the need of expediting the heavy bomber program. With all major nations developing pursuits with speeds of approximately 400 miles per hour, the B-18 type of bomber would be "at the mercy" of these planes in combat. Andrews strongly objected to equipping the GHQ Air Force with low performance medium bombers when four-engine models of superior performance were already available.[37] By supercharging the B-17, he was convinced it could develop a speed of 200 miles per hour at 25,000 feet. As further support for his case, he also pointed out that the British Mission to the United States in 1938 had not even considered the procurement of the B-18, presumably because of its slow speed.[38]

General Arnold several days later added another prop to Andrews' argument by informing the War Department that aircraft manufacturers were not building experimental twin-engine bombers to enter the forthcoming design competition. He recommended cancellation of the competition with the provision that Air Corps requirements would be met with the procurement of all B-17B's possible under the exisitng option. The performance of this airplane had already surpassed the specifications outlined in the latest design circular. He further suggested that in the future the medium bomber would be primarily useful for transitional training of bombardment personnel and units.[39]

Meanwhile, the Joint Board had set a limitation upon the maximum size, range, and radius of action of bombardment aircraft. Its objective had been to determine how existing types could be perfected to meet strategic requirements with stress placed on standardization and decreased cost. Final conclusions reached by the Board did not augur well for the future of the four-engine bomber: "Based on the present situation it is not considered probable that the Army Air Corps will be called upon in war to perform any missions that require the use of reconnaissance and heavy bombardment planes of greater practical ferrying range, greater tactical radius, and greater carrying capacity than those of the B-17." However, it would be called upon to perform missions that could be successfully executed with the B-18 type bomber which was less expensive to build.[40]

Although General Westover, in the past, had adhered as far as practicable to War Department policies, he apparently saw in the recommendations of the Joint Board the death-knell of future four-engine bomber development. In an attempt to revive the long dormant matter of the substratosphere bomber, a report was requested from the Materiel Division concerning the

practicability of holding a design competition preliminary to an experimental project. The report also was to include a cost estimate, the probable date of design competition, availability of funds, a project to which it could be changed, and the proposed military characteristics.[41] General Arnold's request to the War Department earlier that year on the same project was answered shortly after General Westover's memorandum was sent to the Materiel Division. The Assistant Secretary of War informed Arnold that no military requirement existed for a substratosphere bomber, and that General Westover again had been directed to restrict experimental aircraft development to that class designed for close support of the ground forces.[42]

The future of the heavy bomber looked dark in August 1938. Generals Andrews and Arnold had received a definite "no" to their many requests for concentration on four-engine bomber development with a pointed reminder that it was for the "best interests of national defense."[43] The Materiel Division was complaining of its difficulties in conducting bombardment research and experimentation. The Chief of the Division, General Robins, was of the opinion that the restrictive policies formulated by the Bryden Board in 1936 were still hampering Division functions, resulting in shortage of personnel, insufficient funds, and lack of essential engineering equipment for conducting experimental tests. Because of this situation, the Division had been unable to prosecute projects to a degree that was essential to keep pace with foreign bombardment development. They were still forced to adhere to long obsolete military characteristics for bombers since the War Department was trying to keep procurement costs at a low level. Aircraft manufacturers, in view of the trend toward stabilization of design,

caused by the War Department's emphasis on economy were disinterested in developing superior performing bombers.

One statement in the Bryden Report had been considered particularly detrimental to heavy bomber development and procurement. It had pointed out that the romantic appeal of aviation had induced a large section of the public and even a substantial element of the Air Corps to accept the conclusion that future wars would be decided by large independent fleets of super-performing aircraft. This false concept of employment--according to the Report--coupled with the allure of increased speed, range, and size, had led to a striving for the ultimate possibilities in aircraft rather than fulfilling practical military needs.[44] General Robins strongly disagreed with this allegation, because, in his opinion, American aircraft were useless unless they were equal or superior to those of a potential enemy. He alluded to vast sums of money being spent abroad to perfect heavy bombardment airplanes and deplored the obvious disregard of this fact by the War Department. If this condition continued it was bound to result in "grave consequences."[45] High ranking officers of the Air Corps and the GHQ Air Force in 1938 were practically in accord over the myopic perspective of the War Department. They observed with growing concern the accelerated development of combat aircraft by European and Asiatic powers. Although they continued their effort to rescind the existing War Department policies of bombardment aircraft procurement, little had been accomplished.

General Arnold, in the mid-summer, was again manuevering with the War Department in an attempt to obtain reconsideration of the ban on four-engine bombers. He pointed out to General Westover that if certain

recommendations were made regarding medium bomber procurement it might assure the Secretary of War of Air Corps compliance with his desires. Consequently, his attention it was hoped would be diverted from the heavy bombers until additional data was assembled to warrant reappraisal of the action taken in the matter.[46] General Westover, increasingly concerned over the complications and strong opposition encountered in his effort to achieve a workable and balanced aircraft program, once again expressed his views on the unsatisfactory situation to the War Department late in August 1938. He urgently recommended that the procurement of four-engine bombers be continued and that the substratosphere bomber project be started immediately. Original estimates for these aircraft, as set up for 1940, were based on thorough analysis of Air Corps needs and Westover felt that the Joint Board disapproval of further development of four-engine bombers had been unjustified. Unless the Air Corps was able to maintain a comprehensive and progressive aircraft program, there would be no continuity of effort nor efficient planning. Decisions and actions would be based on a "hit-or-miss" basis, depending upon the expediency of the moment, thus creating indecision, uncertainty, and confusion in the Air Corps as well as the General Staff regarding ultimate objectives. He conceded that budgetary limitations might well force revisions from time to time, but these should be only by way of deferment or minor adjustment.[47]

General Westover received an answer in October, informing him that the Woodring Air Corps Program, approved in March of that year, could be used as a guide in formulating annual requests for funds, but that "4-engine bombers will not be included in the estimates for FY's 1940 and

1941 . . ."[48] He was further advised that the War Department was fully aware of the needs of the Air Corps. It was clear that none of the effort of his service to develop superior bombers of greater speed, range, action, and ability to carry heavy bomb loads changed the traditional Army conception that the infantry division was the basic combat element by which battles were won and enemy field forces destroyed. In the future development of aircraft and the preparation of requirements as to type and number of aircraft the Chief of Air Corps was to be guided by the War Department's desire to obtain and develop only such aircraft as were suitable for close support of the ground forces.

Although there could remain little doubt of the War Department attitude toward the heavy bomber, a loophole was inadvertantly provided for the development of the much-discussed substratosphere bomber: the restrictions imposed on experimental development of four-engine aircraft had been declared rescinded.[49] The new Chief of Air Corps, Maj. Gen. H. H. Arnold, seized the opportunity provided by this change of policy to expedite action on the substratosphere bomber project. The Chief of Materiel Division was requested to submit plans for its procurement as originally approved under the Research and Development program for FY 1939.[50]

General Staff Modifies Heavy Bomber Policy: Evidence of growing General Staff interest in heavy bombardment, came to light when Brig. Gen. George C. Marshall, new Deputy Chief of Staff, gave full support to General Arnold's vigorous effort to build up Army airpower with a strong force of heavy bombers. In November, he cited to Chief of Staff General Craig numerous reasons why it was essential to increase procurement of the new turbo-supercharged B-17B: it could operate successfully in spite of partial engine failure; its long range permitted swift reinforcement

of foreign garrisons; it could patrol wide sea areas and protect shipping; it possessed strong offensive power against enemy war vessels; and it could perform far greater counter-air force operation than any existing twin-engine bomber. According to Air Corps standards, the B-18 bomber was obsolescent, and it was actually less expensive to procure the superior B-17 when the cost and effort required per pound of bomb load was considered: four B-18's were necessary to carry the load of one B-17 to any distance up to 1100 miles; the operating crew of one B-17 was composed of only nine members compared to twenty-eight for four B-18's; only eight men were required in ground crew maintenance for one B-17 compared to sixteen for four B-18's. In addition, the initial cost of one B-17 was only $280,000 as against $400,000 for four B-18's. Since the B-17 was considered the outstanding heavy bomber of the world, it was essential, in order to meet the emergency procurement program established by the President for increased air power, to purchase them in maximum quantities within the capabilities of existing aircraft facilities.[51] On 4 January 1939, the President provided the key to the official change in attitude toward bombardment airplane development, as well as to rearmament in general. In his message to Congress on that day he declared that "we have learned that survival cannot be guaranteed by arming after the attack begins--for there is new range and speed to offense."[52] With the growing support of the General Staff, Air Corps leaders in 1939 concentrated upon the experimental development of advanced type aircraft and urged expansion of the bombardment strength of the GHQ Air Force. They also kept a critical eye on the accelerated research and experimentation in airplane design abroad. President Roosevelt also took cognizance of foreign technical

advances, which led him to make the following warning regarding Hemisphere Defense:

> Information from other nations leads us to believe that there must be a complete revision of our estimates for aircraft. The Baker Board report of a few years ago is completely out of date. No responsible officers advocate building our air forces up to the total either of planes on hand or of productive capacity equal to the forces of certain other nations. We are thinking in the /sic/ terms of necessary defenses, and the conclusion is inevitable that our existing forces are so utterly inadequate that they must be immediately strengthened.[53]

Spurred on by such policy a concerted effort was beginning to be made by all Air Corps personnel to obtain a real solution to the manifold problems involved in building up the long inadequate air power of the nation.

In March, the War Plans Division was requested to prepare a comprehensive air force study, based on accepted doctrines of aviation employment. Conclusions reached by two specially appointed committees were to be analyzed and submitted in a final report to the Chief of Staff. The following points were stressed: (1) that the initial air objectives of an enemy would be American air bases in Hawaii, Puerto Rico, Panama, and other exposed areas; (2) a well-led and determined air attack, once launched, could not be stopped by American defenses, although serious losses could possibly be inflicted upon the enemy; (3) it was the duty of the Air Corps to provide a powerful striking force and the necessary strategic bases; and (4) the land-based heavy bomber was declared superior for national security because of its flexibility of employment and strong offensive performance. Further, to prevent the launching of an air attack against the United States, the Air Corps was to have on hand sufficient combat aircraft possessing adequate range and power to reach and successfully

destroy any actual or potential base held by an enemy before he could attack critical areas of the United States and her possessions.[54] This memorandum in its entirety represented a composite view of the varied air power concepts expressed in the past by Generals Mitchell, Westover, Andrews, Arnold, Robins and many other air-minded officers. It was the culmination of the many years of effort spent by bombardment proponents in trying to awaken the War Department to a clearer understanding of the extensive air defense problems and of the ever-growing need of a strong offensive air force built around the heavy bomber.

In the ensuing months of 1939, although some controversial points arose in the bombardment expansion program, the attitude of the War Department underwent a favorable change. Individual opinion was submerged in the coordinated effort to build up sufficient aircraft strength, accelerate pilot and technical training, and expand the tactical and strategical doctrines of air force employment before the anticipated outbreak of a European war. This change of attitude was exemplified in August by the Secretary of War's approval of the procurement within nine months of forty-two heavy bombers of improved performance to meet the shortage of these aircraft in the GHQ Air Force tactical units.[55]

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Chapter III

WAR--THE END OF THE HEAVY BOMBER CONTROVERSY

As the Nazi mechanized legions rolled across Europe in late 1939, following in the wake of the great striking power of the Luftwaffe air fleets, Air Corps leaders were deeply concerned about the continued delay in carrying out plans for augmenting the offensive strength of the GHQ Air Force. Survey of critical military aviation conditions within the service and analysis of the employment of air components by the warring nations had further supported the stand that American air power must match and surpass in size and efficiency that of the belligerents or it would fail in its primary mission to defend the continent and insular possessions on M-Day.

The obvious lesson that was being written in air warfare abroad intensified the imperative need for developing and producing larger and more powerful heavy bombers capable of immediate reinforcement of American frontier garrisons in Alaska, Hawaii and Panama in case of a national emergency.[1] Since basic Air Corps doctrines were predicated on the capacity of an air force to exert its power decisively and with great tactical and strategical mobility, lack of the necessary aircraft having the radius of action to perform those missions, defeated the fundamental purpose for its existence.[2]

In 1937, Maj. Gen. Frank M. Andrews, Commanding the GHQ Air Force, had stated that the United States was in a predicament similar to that of

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many European nations--it had no air frontiers. He had deplored the complacent attitude toward national defense and the failure to properly develop and utilize American air power to the end that "we shall at least be at all times a little bit better than the other fellow." It had been Andrews' contention that the potential resources of the nation were not a substitute for an actual air force. Aircraft which were on the drafting board and in statistical tables of resources and manpower could only become air power in the future--too late for tomorrow's employment.[3] Such a condition confronted Air Corps leaders in late 1939 as they previewed the employment of air power in modern warfare.

Lt. Col. Carl Spaatz, Chief of Plans Division, submitted to the Chief of Air Corps on the same day as Germany's invasion of Poland a searching study of the employment of long range heavy bombardment, particularly in the potential Far Eastern Theater of War. He strongly advocated the immediate development of heavy bombers with superior tactical radius and high altitude performance to that of existing types to insure the success of any strategic offensive air operations which the Air Corps might be called upon to perform.[4]

Since early 1939, Air Corps tactical staffs and Materiel Division engineers, under pressure from Maj. Gen. H. H. Arnold, Chief of Air Corps, had been conducting design investigations and holding conferences with leading manufactures of large capacity airplanes in order to determine the military requirements, characteristics and performance of long range bombers in the 200,000 pound class. As a result, Arnold had been informed that it was technically possible to develop and produce such a bomber capable of a range of 5333 miles with a normal bomb load of 2000 pounds and a

minimum high speed of 300 miles per hour.[5] Shortly afterward, he took definite action to get an experimental heavy bomber project under way by suggesting a plan of development and procurement to the Assistant Secretary of War. It was indicated that the Air Corps Research and Development program for the fiscal year 1940 provided funds for design studies and engineering data for a four-engine pressure cabin airplane of military characteristics and performance superior to those of the B-17 and B-24. In an informal competition, preliminary data was to be solicited from manufacturers qualified and skilled in the production of large high performance military aircraft. Winning bidders would be awarded experimental contracts for wind tunnel models and mock-ups, stress and engineering analyses. Additional tests in the NACA Laboratories would result in complete clarification of the design in accordance with the latest military characteristics.[6]

The proposed bomber would have a tactical operating radius of 2000 miles (5333 mile range) at economical cruising speeds averaging 200 miles per hour or more with a normal bomb load of 2000 pounds. A high speed of 450 miles per hour above 20,000 feet was envisioned with full consideration given to effective bombing and efficient crew functioning. Allowances were to be made for interchangeability of bombs for fuel so that a maximum bomb load of 8000 pounds could be carried for short range operations. Defensive armament was to consist of the gun installations and fire control apparatus necessary to effectively protect the airplane while performing its mission. In view of the new structural design features necessary to produce such an airplane, the Air Corps took cognizance of the compromises that would arise as a result of technical limitations

within the industry. Emphasis, therefore, was placed on simplicity of general design consistent with maximum performance.[7]

The Assistant Secretary of War approved the recommendations and authorized issuance of requests for manufacturing bids. In this connection, Request for Data R-40B was distributed in January 1940.[8] But as preliminary designs and proposals began to flow into the Materiel Division, the observations and reports on the progress of the air war in Europe, dispatched by military attaches,[9] brought about a number of revisions in the original specifications by the Air Corps Tactical Staff. These included such features as leakproof fuel tanks, remotely controlled multiple gun turrets, heavier caliber guns and cannon, armor, and improvement in over-all performance.[10]

As a result of the radical changes dictated by newer employment of combat aircraft abroad, all bid proposals already submitted for the official opening of March 7 were rejected. Considerable difficulty was experienced by the Materiel Division in incorporating the revisions. The paucity of data and information available from the subcontracted manufacturers of fire control equipment, armor plating, leakproof fuel tanks, and other important accessories, resulted in confusion of requirements because of insufficient time for these organizations to study the application of this equipment to military aircraft.[11]

Upon resubmission of new bids on project R-40B in May, an Engineering Committee and Evaluation Board selected as the winning bidders Boeing and Lockheed.[12] Later Consolidated was added as a third source of procurement in light of the high priority that had been assigned to this development by the Secretary of War.[13] The Boeing Aircraft Company, with its long experience in constructing the B-17 and B-15, was authorized in September 1940 to produce the first very heavy bomber to incorporate pressure-cabin

installations and other radical changes in design and armament. It was later designated the XB-29.[14] And while Lockheed Aircraft Corporation, which had intended to revamp the "Constellation" (C-69) then under development into a bomber, was later forced to withdraw its bid because of the heavy demand for its P-38s, Consolidated Aircraft Corporation was awarded a contract for an experimental model known as the XB-32.[15]

Air Corps Expansion Program and Hemisphere Defense: While the aircraft manufacturers were preparing bid proposals for Request for Data R 40B, General Arnold was studying future procurement plans for heavy bombers authorized in the Air Corps Expansion Program. The Assistant Secretary of War had informally requested the opinion of General Arnold regarding the possibility of purchasing five hundred service type heavy bombers for FY 1940 to the exclusion of other aircraft models. Arnold advised that two hundred and eighty-seven bombers should be procured in the 500 Program for that year, since he questioned if any number in excess of that amount would be approved by the Bureau of the Budget and Congress. This decision was based on the estimated requirements for heavy bomber groups and long range reconnaissance squadrons to be assigned to the continental United States and insular possessions.[16]

In the Spring 1940, however, General Arnold advised Secretary Woodring that total numbers of airplanes were often a misleading criterion of the relative air power of the nation. Once again he emphasized the importance of the long range heavy bomber in hemisphere defense, pointing out that Germany's ability to perform long range bombardment missions was approximately four times that of the Allies. He declared that if England had possessed more long range bombers she could have been more effective in offensive warfare.[17]

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The new Commanding General of the GHQ Air Force, Maj. Gen. Delos C. Emmons, shared General Arnold's view on long range heavy bombers, for in June he wrote at length to the Chief of Air Corps on this matter. He advised Arnold that the Air Corps must avoid making the same mistake that the British had made by building up a sizable defensive air force consisting largely of interceptor fighters and light reconnaissance bombers, when there was a great need for long range heavy bombers to conduct strategic operations. He pointed out that the tremendous German forces engaged in Northern France had England on the flank of their lines of communication-railways, waterways, and roadways jammed with troops and materiel moving to the front--all extremely vulnerable to continuous air attack. Although these forces were well within range of British medium bombers, the RAF was unable to concentrate sufficient numbers of aircraft to effect disorganization on any major scale. Emmons believed that never before had such an opportunity existed for England to apply air power for securing decisive results, and the lack of heavy bombers would undoubtedly prove costly. In view of this he strongly advocated acquiring with a minimum of delay a strong force of long range bombers to defend America against actual or threatened air attack.[18]

General George C. Marshall, Chief of Staff, also received a lengthy letter during the same month from Brig. Gen. J. E. Chaney of the Air Defense Command, regarding the imperative need for developing and producing large numbers of long range bombers. It was believed that a huge force of bombers, capable of carrying war and destruction to Berlin, would prove a constant threat to German aggression and provide counter air force operations against any attempt she might make to establish bases in or

near the Western Hemisphere.[19] General Chaney's suggestions were concurred in by General Andrews, Assistant Chief of Staff, the War Plans Division, and General Arnold. The latter elaborated on some of Chaney's remarks, emphasizing the importance of range in bombardment aircraft and the preponderance of this type of aircraft needed to assure successful defensive action in case of war. The Nazi occupation of Holland, Belgium, and France, and the inability of England to offer resistance because of lack of offensive aircraft, were cited as clear examples of the condition that might confront the United States. A stong air offensive had obviously become an essential prelude to successful strategic action, and this was possible only through the employment of long range bombers.

The Chief of Staff was further advised that the Air Corps Research and Development Program for Fiscal Year 1941 had been so set up that a large portion of development effort would be allocated toward procuring long range bombers superior to all existing equipment.[20]

During the closing months of 1940, the Materiel Division, in conjunction with Boeing and Consolidated, concentrated on the initial experimental development of long range bombardment airplanes equipped with pressure cabins and strong fire power. They were working against time, since the critical war conditions abroad had pointed to the urgent need for mobilizing a huge air force primarily composed of heavy bomber types. The Battle of Britain had started in August and was increasing in tempo as the Germans launched sustained mass day bombing attacks against military and non-military objectives. In early October, after heavy attrition, the Luftwaffe had shifted to night area bombing which continued until the end of the month, at which time the Battle of Britain ended in a stalemate. The significant

lessons learned by Air Corps strategists and tacticians from the blunders made by the Luftwaffe in its aerial assault upon England were being assiduously applied to the development of American heavy bombardment aircraft in preparation for the day when war would embroil the nation.

Increased Coordination--All-out Bomber Production: In 6 January 1941, General Emmons, Commander of the GHQ Air Force, in an inspection of the mock-up of the Consolidated XB-32, was critical of some of its features, but advised the Chief of Air Corps that the long range pressure cabin bomber would be of great value in overriding storms and in bombing such large and well-protected targets as Berlin. He did not favor, despite the need, the production of this type of bomber until problems such as fire control, defrosting, armor, leakproof fuel tanks, and other important equipment had been solved to insure successful high altitude precision bombing.

Shortly after this inspection the GHQ Air Force complained that it had not been properly consulted on the design of bombardment airplanes with which it was to be equipped and was not afforded an opportunity to coordinate on the specifications finally evolved. Although officers of the organization served on Mock-Up Boards, their duties had been to make detailed recommendations for the improvement of a bomber which had already been partially designed and which conceivably might have unsatisfactory features that could not be corrected at that stage. Proceedings of the Mock-Up Board had not been transmitted to the Commanding General of the GHQ Air Force for concurrence, and therefore it was impossible to determine whether important changes had been incorporated. It was recommended that in the future that this matter be coordinated with his headquarters before final action was taken.[21]

General Arnold later replied to General Emmons' letter and presented the following comments regarding Emmons' criticism of established procedures for the development of experimental bombardment aircraft: Emmons' inspection of the XB-32 mock-up had preceded by one day the scheduled meeting of the Mock-Up Board; the proposed changes he (Emmons) had recommended had been discussed and considered during the subsequent sessions and necessary corrections were made. Further, since the conception of the project in 1939, and while the Air Corps and aircraft industry had long been working on a substratosphere airplane development, great impetus had been given to the bomber project as a result of Joint Air Corps and Anti-aircraft Artillery exercises at Fort Bragg, North Carolina, late in 1938. At that time, the application of experimental pressure cabin installations to bombers to permit extreme high altitude operation and avoidance of anti-aircraft fire, was deemed imperative. The GHQ Air Force had made specific recommendations to that effect upon termination of the exercises. In the XB-32 and XB-29 projects, the pressure cabin feature, together with remotely controlled multiple gun turrets, had been stressed throughout and the omission of the former in particular would represent a distinctly backward step in the development then in progress, especially in light of combat operations abroad.

Subsequent to the initiation of the substratosphere project, the R-40B data had been presented in detail to all members of the Emmons Board at a meeting at Wright Field in May 1940. At that time, the Secretary of War had authorized a high priority for the project and recommendations had been made by the board to expediate to the fullest possible degree. Arnold emphasized that the British were rapidly pushing pressure cabin development, endeavoring to pressurize for 40,000 to 45,000 foot operations.

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They were intensely interested in seeing the XB-32 project consummated since their own extremely high altitude equipment was usable only for short periods of time, due to unreliability of standard oxygen equipment.

In connection with coordination between the Materiel Division and the GHQ Air Force regarding bomber specifications, General Arnold indicated that representation and cooperation did exist throughout the formulation and preparation of the general military characteristics for combat aircraft. It was during this stage that decisions were reached as to performance, armament, radio, and miscellaneous equipment requirements. The mock-up inspection, at which the GHQ Air Force was represented, served to furnish as nearly as possible a rough picture of what the finished product would be. That time period between the formulation of plans, approval of the Materiel Division, and the mock-up stage, represented an essential period for the preparation of specification requirements, circular proposal data, method of evaluation procedure, preliminary design and engineering studies, innumerable conferences with industry representatives, contract negotiations, together with discussions of the inevitable and necessary compromises in arriving at the optimum obtainable. Throughout this transitional phase, changes were constantly occuring, based on engineering studies as they progress, at lessons learned from combat operations abroad, development of new materials, new and improved engines and propellers, and so on. To effect complete coordination during that period would require constant interchange of correspondence with reference to designers' handbooks, manuals, detailed drawings, and other engineering data not always readily available in quantity or suitable form for distribution. Arnold believed that an attempt to coordinate all activities with the GHQ Air Force during the developmental stages would add one more

link to the seemingly unending chain of delays incident to evolution from drawing board to the flying line. Finally, to circumvent this barrier, it had become general practice for members of Materiel Division staff to frequently visit Headquarters of the GHQ Air Force to discuss essential elements of bomber specifications and to effect coordination on all basic items pertaining to combat airplanes.[22]

While this fundamental problem of internal coordination was being ironed out, or at least explained, several important matters arose within the Air Corps Staff regarding the role of the heavy bomber in the event of war. Brig. Gen. Carl Spaatz, Chief of Plans Division, advised Maj. Gen. George H. Brett, Assistant Chief of Staff, that as soon as air warfare became serious the demand was always for heavy bombers. The British had found themselved committed to a program which provided short range aircraft in relatively large quantities, whereas, their situation actually demanded long range airplanes. Spaatz felt that the situation of the United States when fighting alongside of Britain would be similar, and when fighting in defense of the Western Hemisphere, it would be considerably worse because of the much greater distances to be covered. It was therefore evident that every effort should be made to expand as rapidly as possible the nation's capacity for the production of four-engine bombers.[23]

The increased production of those bombers was also a matter of great concern to the President of the United States. In May he advised the Hon. William S. Knudsen, Director General of the OPM, that he knew of "no single item of our defense today that is more important than a larger four-engine capacity".[24] On the same day, he directed Secretary of War Henry L. Stimson to arrange for the expansion of heavy bomber production

to 500 per month, pointing out that command of the air by the democracies must and could be achieved and that every effort must be expended to hasten the process.[25] In each case, the importance of promptly obtaining preferential priorities for materials and components going into the heavy bomber program was strongly stressed. Several days later, the Assistant Secretary of War (Air) advised the Chief of Air Corps that in stepping-up heavy bomber production "the job is now up to us." This matter was of such urgency, with respect to both the preparation of the country for the unknown future and the fullest measure of aid to Britain, that it should be given the "right of way and made the first concern of everyone in the Air Corps."[26]

For many years, General Arnold, along with Andrews, Robins, Emmons, Spaatz, had aimed at this goal--full acceptance of the four-engine bomber as the basic weapon of air power and the removal of all restrictive bans on its production. Acknowledgement by the Chief Executive and the War Department that this aircraft was vital in order that "democratic superiority in the air be made absolute" spurred him to further action, resulting in the preparation of preliminary military characteristics for design studies of a longer range, higher altitude heavy bomber than the XB-29 and XB-32 which were at that time in the final stages of experimental development. The proposed new substratosphere bomber was to have four or more engines, a desired high speed of 450 miles per hour at 25,000 feet, a maximum range of 12,000 miles, a service ceiling of 45,000 feet, and was to be capable of carrying a crew of sixteen. The minimum performance required approximated the maximum guaranteed performance of the abovementioned models. The design to be studied was to provide for a 10,000 pound bomb

load to be carried 10,000 miles. Interchangeability of at least 80 per cent of the fuel required for a 12,000 mile range was to be provided. Defensive armament would include remotely controlled gun installations with 20 or 37 mm. cammons, armor plating for principal crew members, and leak proof fuel tanks.[28] Subsequently, this design study culminated in the experimental development of the Northrup (XB-35) four-engine (tailless) flying wing bomber and the Consolidated (XB-36) six-engine model of conventional structure.[29]

Earlier in June 1941 the Chief of Air Corps, Maj. Gen. George H. Brett, had informed the Assistant Chief of Staff, War Plans Division, that the figures on air force requirements, in spite of General Arnold's (new Chief of Army Air Forces) emphasis on heavy bombardment, and in spite of Great Britain's plea to the United States for more heavy bombers after having admitted that she had erred in not placing sufficient stress upon that type, were not in the ratio desired. Practically no increase in bombers had been planned which was contrary to the desires of the Chief of the Army Air Forces and the Chief of Air Corps. Brett pointed out that the Germans had reversed the ratio of bombardment and pursuit compared with the War Plans Division ultimate objective of 35 per cent of air strength composed of the former aircraft.[30] General Arnold echoed these sentiments when, in July, he advised the Assistant Chief of Staff, War Plans Division, that the GHQ Air Force was "at zero strength as far as any major war is concerned." Not one of the available combat bombers had adequate fire power, few of them had turrets of any kind, and very few had leak-proof tanks or armor. If M-Day had occurred at that time, only two partially equipped Heavy Bombardment Groups could have been mustered for immediate reinforcement of Alaska, Hawaii and Panama. The Army Air Forces could not engage in any major war in September 1941.[31]

[redacted]

Projected Role of Bomber in Air Warfare: In August 1941, Brig. Gen. Carl Spaatz, Chief of the Air Staff, directed that the Air War Plans Division prepare a careful study covering the relatively distant future and the immediate future development of large, quantity-production, bombers. The following points were to be considered: the Air Forces military mission; radius of action of existing bomber types; reinforcement of the Philippines; strategic requirement for the defense of the Western Hemisphere and insular possessions; tactical and strategical employment of the Air Forces in probable theaters including targets which must be attacked; joint action with the Navy in any operational matter; available air bases; the size of airplane as may be limited by industrial restrictions and economic considerations versus the size needed for operational requirements and military missions; the size of crews with their duties analyzed, based on experiences in air warfare abroad and viewed from the training angle; and the probable combat performance and defensive armament required. Upon completion of this study, a thorough comparison was to be made with long range bombers under development and a decision made as to the earliest production date and the changes in plans necessary for achieving maximum production with the minimum of man hours and expense.[32]

The following month, the Chief of the Experimental Engineering Section, Materiel Division, informed the Division Chief that everything possible was being done to expedite completion of studies in connection with the long range bombardment project and that negotiations were proceeding with the Northrup Aircraft Company for the construction of one model of the flying wing bomber as authorized in the conference held between General Arnold and General Echols on 9 September.[33] Negotiations were also underway

with Boeing, Douglas and Consolidated, preliminary to a contract for engineering studies of a design capable of meeting the above range-bomb load requirements. Actual dates of the completion of experimental types could not be predicted, but it was estimated at two and a half years. Limited production could possibly be initiated in from 12 to 18 months after construction of experimental models.[34]

In a general revision of the Air War Plan, General Spaatz pointed out to the Assistant Chief of Staff, War Plans Division, in October that the Army must lose no opportunity to insist upon exercising its right to conduct air operations within the tactical operating radius of its aircraft, and that the Air Forces did and could operate in lieu of naval forces. The purpose of this change was to counter the recurring Navy argument to substitute four-engine land bombardment airplanes for their patrol boats which, if agreed to, would cut into the organization of the heavy bomber groups of the Combat Command.[35] At that time, there were only 83 heavy bombers (B-17's) in the continental United States and 31 at insular stations. 47 of the total in the United States were suitable for the formation of one group and one squadron (40 had leakproof tanks and armor and 5 had turrets). At Pacific and Carribean Stations, the 31 B-17's were all equipped with leakproof tanks and armor but none had turrets.[36]

Secretary of War Stimson, several days later, presented to the President his view in brief of the strategic employment of heavy bombers. He indicated that the new bombers coming off the assembly line should constitute a great pool of American power applicable with speed and mobility to the respective points where, in the interest of national defense, it was important that such power be applied. The melancholy list of casualties that had lately occurred to American bombers in the hands of the British

was a sharp reminder of the danger of trying to send to combat such planes in the hands of hastily trained crews.

Since the panorama of the theaters of action for the nation's defense were constantly and rapidly shifting, the number of heavy bombers located at strategic points must be liable to swift reinforcement and/or change. The ability to concentrate great massed air strength at a given place at a given time was one of the essential elements in effective use of air power. Stimson pointed out that Germany, in her use of air power had shown supreme skill along that line. The fate of the European war conceivably might hang upon the length of time within which America could amass an overpowering force of heavy bombers in a given theater.

He emphasized that the constant Japanese threat in the Pacific exemplified the importance of his previous statements. A strategic opportunity of utmost importance had arisen in the southwestern Pacific and the Air Forces were rushing heavy bombers and other equipment to the Philippines from a west coast base which did not have sufficient aircraft to meet the immediate minimum requirements distribution in its own area. American deferments to the British in 1940 had resulted in shortages in the rearming of the Air Forces, since from nowhere else could the needed planes, crews, equipment and training be supplied.

Stimson further believed that the northern Atlantic was the main theater of the war. America was already in actual naval combat with the Germans. The heavy bombers that were proposed to reinforce Newfoundland were to serve as a reserve component of a "team" of such airplanes spanning the Ocean from North America to Europe, the advance unit of which was to be in Iceland. But deferments to Great Britain had delayed establishment of the necessary bases, and at that time there were only six heavy

bombers in Newfoundland and none in Iceland. Finally he stressed the great importance of devoting primary attention to the prompt development of the American Air Forces. He deemed it unwise therefore to divert further production to Britain until at least minimum defense requirements were fully completed, since safety of that principal "bastion" in the Northeast could not be secured by a comparatively insignificant trickle of heavy bombers, unequipped, unmanned, and unorganized for battle operations.[37]

Thus, on the eve of Pearl Harbor, primarily because of the diversion of aircraft to aid Great Britain against the advancing might of the Nazi war machine, America was, as General Arnold had earlier pointed out "at zero strength" to engage in a global war.

Combat Bombardment Methods--American and British: After the Japanese attack on December 7, the leaders of the Army Air Forces were faced with a two-fold task: to build up a powerful striking force of heavy bombers and deliver them to potential theaters all over the world while still supplying the urgent aircraft needs of the Allied Nations. No other Army in military history had been called upon to perform such a gigantic undertaking. The shortage of shipping, the constant submarine menace, the long distances involved over water and land, and the urgency for reinforcement and materiel made it essential to establish as quickly as possible a huge network of global routes.

When the Japanese attacked, the Air Forces had only 61 heavy bombers at various bases outside the United States, and these were thinly apportioned to strategic areas in the Atlantic and Pacific. The few B-17's that escaped destruction on the ground at Pacific bases, proved their inherent ruggedness against concentrated air attack, despite inadequate defensive fire power, lack of leakproof tanks, armor, and fully trained crews. In

the ensuing months of 1942, therefore, every effort was directed toward the fulfillment of the Air Forces Victory Program--designated as A-WPD-1--which included concentration on the development of the 10,000 mile sub-stratosphere bomber.

For many years, Air Corps leaders had believed in a balanced bombardment program. Bombing doctrines and methods of employment had been directed toward one ultimate goal--successful performance of the Air Force mission on M-Day. Along with the physical development of the high altitude, long-range bomber, methods of bombardment were being constantly improved. Before the war, horizontal precision bombing had become the accepted doctrine of the GHQ Air Force, and subsequent events in the European and Far Eastern theaters of war demonstrated its soundness.[38]

Broadly speaking, targets for air attack were either fixed or moving. In the thirties, GHQ Air Force bombardment units had practiced extensively against fixed tagets, but practice against the most difficult of targets, highly maneuverable naval vessels, had necessarily been limited. The Commanding General of the Army Air Forces, Lt. Gen. H. H. Arnold, however, had believed that if bombing operations against moving objectives were limited to dive bomber types of airplanes, the effectiveness of the Air Force would be restricted.

The British had strongly challenged American bombing methods and the capability of American bombing aircraft to meet effectively the requirements of actual combat operation, in which success could be judged only in the light of tangible results. To ensure the greatest success possible, the Army Air Forces adopted every conceivable means of improving both its bombardment aircraft and the accuracy of its bombing methods. In a memorandum on this subject to the Air and Field Staffs, General Arnold urged initiative

and energy, resourcefulness and determination, in the execution of combat missions "in order that we may produce results of maximum effectiveness and mental flexibility and courage at all times so that the breaks of battle will be of our making and to our advantage!"[39]

The first official assault of the United States VIII Bomber Command against occupied Europe was launched on 17 August 1942, when 12 B-17's attacked targets at Rouen, France, from an altitude of 22,500 feet. It was a critical test for the American bombers, not because of the size of the effort, but because the future of high level daylight precision bombing was at stake. Pressure for action in the European theater had been steadily mounting, both in America and Britain, but there were many skeptics who predicted dismal results from this mission. It was, however, deemed a success. All bombs had been dropped on or near the target; there were no casualties; good escort cover was provided by RAF Spitfires; there was slight damage to one Fortress from flak; and a few encounters were made with enemy fighters.

In view of the fact that the British Bomber Command had developed its heavy bombers for night missions and that American aircraft were developed for daylight operations, joint operational plans were laid that would permit round-the-clock bombing of enemy targets. In the British Lancasters, Halifaxes, and Stirlings, speed and armament were limited in favor of long range and heavy bomb loads. These airplanes were especially effective for night attack on industrial areas where a high degree of precision bombing was not vitally necessary. On the other hand, the B-17's and B-24's were fast, heavily armed and armored, high altitude airplanes in which limited bomb load was compensated for by the perfection of their precision bomb sights, permitting small specific targets to be singled out for destruction in daylight attacks.

The tactical advantages of a combined bomber offensive were obvious. Enemy defenses had to be alerted continuously causing confusion in their industrial work schedules, and since the Luftwaffe was set up in independent commands, this would result in heavy drains on fighter strength on the active fronts. From the standpoint of the Allied effort, the use of the two bomber forces by day and by night would simplify the traffic problems over bases and the checking system in the costal areas over which the bombers would pass on their missions. Area and precision bombing operations also facilitated joint planning since the British could select a specific city as a target but avoid selected objectives whereas the Americans could concentrate on the destruction of an important plant in the same city. On this basis, then, the two commands could work harmoniously and effectively.

In August 1942, after the highly successful RAF bombing of the Renault works at Paris, General Arnold was advised by Air Marshall Arthur T. Harris, RAF Bomber Commander, that no matter what happened in the interim, or where it happened, the war would become a straight air war between the Allies and Germany. He believed that Britain and America possessed adequate air power to knock Germany out of the war in a matter of months but declared that continued diversion of bomber strength prevented full concentration of the power needed to accomplish that task. Harris was convinced that the United States and Great Britain ran a major risk of encountering the very defeat which they were capable of inflicting upon the enemy because of the "opposition of vested interests and the mentally blind." General Arnold was requested to keep the patent fact to the fore that everything the "Sailors and Soldiers" so violently asserted throughout the past 25 years about air power had proved in the "bitter test of war" not only to be wrong but to be almost diametrically opposed to that which had in fact occurred. Everything which the airman had

equally loudly asserted had proved not only to be right but in most cases had been underestimated. Harris reiterated that the enemy could soon be defeated by air power "if we are not first defeated by our friends."[40]

Shortly afterward, Lord Hugh Trenchard, founder of the RAF in World War I, in commenting on the existing Anglo-American war policy, strongly emphasized the fact that if a right decision regarding the employment of air power was made immediately and tenaciously adhered to it was easily possible to increase the scale of heavy bombing attacks against Germany to approximately ten times the current operations. He indicated that the British air war policy was half-hearted and feeble and that the RAF Bomber Command was the "Cinderella" of the armed forces.

Lord Trenchard further pointed out that the policy of victory by land forces entailed stupendous drains on materiel and on manpower. Air, the new dimension, the new power in military science, had given the Allies a great alternative. If the decision was made to use it with determination and concentration millions of lives would be saved and the war shortened by months--perhaps by years.[41]

These strong British views, of course, coincided with oft-expressed beliefs of Air Corps leaders that the heavy bomber was the basic weapon of air power. Massed employment of these airplanes could deliver devastating blows to enemy industrial centers and strangle the flow of war materiel to his fighting fronts. The bone of contention, however, between America and British airmen concerned the method of employing the heavy bomber. The British favored night area bombing and the Americans favored day precision bombing. Each was adamant about their chosen policy.

General Arnold, in comparing the bombing capabilities of the Army Air Forces and the RAF, pointed out to the Chief of Staff that, based on

a study prepared by General Spaatz, daylight precision bombing, as planned and executed by the Eighth Air Force was conservatively estimated as having twice the effectiveness of the broad, area-target night bombing of the RAF Bomber Command. He gave tentative figures of the bomb tonnages of both air forces which showed that by September 1942 the Eighth Air Force would drop 1740 tons compared with 6009 tons by the British. But, by February 1943, the Eighth Air Force tonnage would be increased to approximately 12,048 tons against 9805 tons of the RAF Bomber Command. In view of that possibility, General Arnold was convinced that with increased effectiveness of precision bombing the Eighth Air Force in conjunction with the RAF would strike heavy day and night blows against Germany's war industrial centers. He believed that every effort should be made to adhere closely to the original plans for the Eighth Air Force and permit only the most vital diversions of air strength to other theaters.

General Marshall was further informed that General Spaatz was studying the effect of bombing German fighter aircraft factories of which there were ten within 550 miles of the United Kingdom. Preliminary studies had indicated that their production could be reduced by one half (1080 airplanes) over a four month period by 600 heavy bomber aircraft missions.[42] The vital part that heavy bombardment was to play in winning the war was reiterated by General Arnold in December 1942 in a memorandum to the Air Staff. He believed that the AAF must concentrate all the bombers possible in the European Theater for mass action against Germany. Sustained heavy bombing on an increasing scale would eventually break Nazi morale and thus assure, in the final showdown, comparatively easy invasion of the continent by Allied ground forces. "In my opinion after we lick Germany

it will not be much of a job to lick Japan. Russia will help us by giving us operating bases in Siberia and we will be able to move up through the islands."[43]

In the succeeding months of 1943, the Army Air Forces continued to build up its air strength in the various theaters. Emphasis was placed on heavy bomber procurement so that long range operations could be intensified against enemy targets as a prelude to invasion by naval and land forces.

Daylight precision attacks launched against Axis objectives in European and Pacific theaters, although on a small scale in 1942, were gradually increasing in magnitude and effectiveness. The coordinated round-the-clock bomber offensive conducted by the British Bomber Command and the Eighth Air Force against "Festung Europa" was conclusively demonstrating the powerful striking power and destructiveness of the heavy bomber. American Fortresses and Liberators, in particular, were justifying the faith of the AAF leaders in daylight precision bombing. Ever deepening penetration of the German antiaircraft and fighter defenses was being achieved and devastating blows were being delivered to vital objectives. The strong Luftwaffe reaction to these missions furnished definite proof that the heavy bomber, despite its deficiencies, was the prime weapon for cracking the industrial power of the Axis.

Chapter IV

MATERIEL DIVISION DEVELOPMENT OF THE HEAVY BOMBER TYPES

When the Materiel Division was organized in 1926, it had one main objective--to develop superior combat aircraft for the Army Air Corps. Its predecessor, the Engineering Division of the Air Service, had a like objective, but in the early twenties the many unfamiliar technical problems that arose necessitated intensive research and experimentation.

The design and development of heavy bombardment aircraft had presented a most difficult project for the Engineering Division. With only limited technical data available on the bomber from the late war, decisions had to be made as to whether future service models should be of large capacity and slow speed or of small capacity and high speed. To study this matter, it was necessary to provide more accurate methods of stress analysis and calculation of flight performance; to improve air-cooled and liquid-cooled engines for increased horsepower; to develop better fuels and lubricants; to determine maximum armament and bomb load; to seek more satisfactory substitute materials for general construction; and to eliminate propeller vibration in radial engines.[1]

The accomplishment of these basic engineering objectives required adequate funds. The War Department, however, in accord with the national economic trend, provided only a limited budget for aircraft research and experimentation. In addition, the development of large and expensive service airplanes for offensive operations was generally disapproved

because of the traditional military policy of defense and non-aggression.* In an attempt to stay within these budget limitations, the Engineering Division utilized the services of the National Advisory Committee for Aeronautics[2] and encouraged independent research and experimental laboratories in the aircraft industry. Also, under the guidance of the Engineering Division, engine and instrument manufacturers, and organizations supplying fuels and lubricants, initiated supplementary programs so that military aircraft development, so far as practicable, would be well-balanced. While this theoretical research in bombardment aircraft construction was considered of prime importance, it was the general opinion of the Division engineers that actual construction of experimental models for extensive performance testing was highly essential to facilitate the heavy bomber project if the production of mediocre service models was to be avoided.[3]

Early Types ** The first American Army bomber, a twin-engine biplane design of the Glenn L. Martin Company, was successfully flown in August 1918.[4] Subsequent performance tests conducted at McCook Field in Dayton, Ohio, proved this bomber--later designated model MB-2 to have acceptable military characteristics and it was procured as a standard service type. The wing span of the Martin was 71 feet, its length 44 feet, and its over-all height 14 feet.[5] At sea level, it had a high speed of 98 miles per hour, equipped with two of the latest liberty 12 cylinder engines of 400 horsepower. With a gross weight of

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* See Chapter I above.

** See Appendix B for specification chart for bombers discussed in this and the following chapter.

12,075 pounds, including a 1500 pound bomb load, the MB-2 was capable of an altitude of 7700 feet.[6] Armament consisted of three flexible Lewis machine guns, one mounted in the front cockpit, one in the rear, and another in a tunnel arrangement under the fuselage.[7]

For its time, this prototype of American heavy bombers possessed many flight characteristics superior to existing Allied bombers, such as the Italian Caproni and the British Handley-Page, and it was recommended by the Division of Military Aeronautics that the Martin replace these models in future production for the Air Service.[8] A modified model of the MB-2 participated in the epochal bomber versus battleship contest held off of Hampton Roads in June-July 1921, conducted under the supervition of Brig. Gen. William Mitchell, Assistant Chief of Air Service, in charge of Training and Operations.[9]

A new trend in bomber design, designated the DB-1, was offered by the Gallaudet Aircraft Corporation in 1921. Built of steel and duralimin around the "W" engine developed by the Engineering Division, it had a novel internally-braced monoplane wing. When later performance tested at McCook Field, however, this model was found to have faulty flight characteristics caused by poor over-all construction and a heavy engine.[10]

Another departure from conventional bomber construction in the same year was represented by the giant, multi-engine Berling NBL-1, a special design of the Engineering Division. It was the largest American airplane of its time, having a tri-plane wing with a span of 120 feet, an over-all length of 65 feet, and a height of 27 feet. Six Liberty 12 cylinder engines of 420 horsepower (four tractor and two pusher) gave it a high speed of 93 miles per hour with a service ceiling of 10,000 feet, and at an approximate gross weight of 41,000 pounds it carried a normal

bomb load of 5000 pounds. Although this mammoth bomber established a number of endurance records, it was considered impractical as a standard service model because of slow speed and extensive maintenance.[11]

With the exception of the Curtiss NBS-4 "Condor", produced in 1924-25, progress in bomber development lagged during the next few years. The Conder was a cleanly designed twin-engine biplane with a wing structure composed of three main sections; the outer sections, which were two-bay, could be folded back paralled to the fuselage for storage. The fuselage was of steel tubing, braced with wire, and streamlined nacelles housed two Liberty 12 cylinder engines of 420 horsepower. The flight performance of the NBS-4 was considered above the average for a conventional type since it had a high speed of 103.5 miles per hour and service ceiling of 13,400 feet. Normally, its bomb load was 2000 pounds, but this could be increased to maximum of 3600 pounds.

In 1924 Maj. Gen. Mason M. Patrick, Chief of Air Service, indicated his dissatisfaction with the slow progress being made in bomber design and development, and directed the Engineering Division to accumulate all data on the heavy bomber and to prepare it in the form of a circular design proposal for distribution to the aircraft industry.[12] The Division was also requested to advise of the proposed expenditures and of any methods devised to transfer funds from other projects to conduct the necessary experimental development.[13]

The Division had been studying the advantages and disadvantages of single and multi-engine heavy bombers for some time, and in early 1926 the Chief of the Division submitted his recommendation to the Chief of Air Service. He did not favor the construction of four-engine models for service use for the following reasons: high production costs; difficult operation due to great size; complication of engine controls

and lack of maneuverability; increased maintenance problems; mammoth structure approaching the Barling NBL-1; reduced cruising range with heavier bomb load; and higher fuel consumption as a result of additional engines. It was conceded, however, that such a bomber would have an excellent rate of climb and better performance with partial engine failure than the latest twin-engine types which, at that time, could not maintain altitude on one engine.[14]

Although this prevailing attitude did not constitute official disapproval of the four-engine bomber as an experimental project, general opposition in the War Department toward large, expensive airplanes mainly retarded its development in the twenties. Engineering efforts, consequently, were concentrated upon improving the military characteristics of existing twin-engine service models, although research continued for designs of a multi-motored, all-metal, thick-wing monoplane with roomier fuselage.

Brig. Gen. William Mitchell, long an advocate of the heavy bomber for national defense, in his capacity of Assistant Chief of Air Service, had often urged the experimental construction of airplanes of this type, with increased high altitude speed, improved fire power, and longer range. He advised his Chief, after reviewing an Engineering Division report on proposed heavy bomber development, that it was "very important that we start this as soon as practicable."[15]

An airplane most nearly incorporating the foregoing features was submitted in a heavy bomber design competition in April 1925. The Kirkham Air Products Corporation, one of ten bidders, offered plans for a twin-engine monoplane offering many radical departures in structural arrangement and greatly improved armament installations. A deep fuselage was proposed with interior quarters for the pilot and crew, an internal

bomb bay, and arrangements for two remotely controlled flexible machine guns in the leading edge of the wing. It also provided for an upper rear gunner compartment and a possible nose turret. The tapered thick wing had a span of 100 feet which, at that time, was an exceptional engineering design, and the power plant was to consist of two geared 500 horse power engines. Performance characteristics, however, were not specified. Although the officers judging the designs favored the immediate development of this "ideal bombardment" airplane for experimental testing, it was estimated that at least two years would be required before the model could be placed in production.

Meantime, it was necessary to replace the obsolete Martin NBS-1 and the obsolescent Curtiss NBS-4 with a stop-gap biplane bomber. The single-engine design submitted by the Huff-Daland Company, later designated the XHB-1 "Cyclops", was selected for this purpose, despite the fact that the trend was away from this type of airplane and toward long-range heavy bombardment.[16] When delivered in 1926, the XHB-1 was the largest single-engine biplane bomber of all-metal airframe construction (fabric covered) yet produced. It had a gross weight of 16,000 pounds, a wing span of 85 feet and length of 59 feet 5 inches. Equipped with a Packard 760 horsepower engine, this airplane had a high speed of 101 miles per hour, a ceiling of 11,000 feet and a bomb capacity of 4000 pounds. Despite some desirable characteristics, however, the XHB-1 did not prove a successful service airplane because of the considerable maintenance required for both the engine and the general structure.[17] In addition, there was a growing tendency in the service to develop only multi-motored bombardment models. Pilots wanted the increased safety factor of two or more engines in case of partial engine failure while performing missions, especially over water.

Until the mid-twenties, the construction of large, multi-engine monoplane bombers had proved difficult because of the lack of methods for precisely calculating the torsional strength of internally-braced airfoils and insufficient equipment for conducting other required experimental tests. As late as June 1926, when the Materiel Division was created, the general design of the newest biplane service bombers still showed little improvement in aerodynamic structure over that of the Martin MB-2 of 1920. Most of the service models were underpowered, with high speeds remaining between 90 and 125 miles per hour; bomb loads were small in comparison with the gross weight; altitudes attained with full military load rarely exceeded 13,000 feet; and normal radius of operation varied between 200 and 300 miles. Much of the delay in developing superior bomber types was attributed to the unfavorable attitude of the War Department toward a strictly offensive airplane and the resulting meagerness of appropriations allowed for research and experimentation in the bombardment field.[18]

Early Multi-Engine Types: The need for replacing outmoded biplane service bombers with multi-engine monoplane types was being strongly urged by the Materiel Division. By the Autumn of 1926, plans had been definitely formulated to restrict future heavy bomber design to two or more engines. To this end, special meetings of a newly formed Bombardment Board had been held to evaluate military requirements based on all available engineering data and equipment, service experience, and the construction of mock-ups embodying ideal arrangement of quarters and equipment. These meetings had culminated in the drafting of new specifications for standard multi-engine bombardment designs which were circulated to interested

manufacturers. Several different models were needed in order that comparative tests could be made with the idea of adopting one or more for general service testing.[19]

A circular design proposal was also distributed in 1926 requesting engineering data for a new and improved type of long range heavy bomber, capable of meeting the latest requirements established by the Bombardment Board. It was contemplated that a study of the designs, test data of experimental models, combined with reports of tactical and strategical employment of service test bombers, would permit the introduction of a definite program for eventual procurement of advanced experimental types.[20] It was generally assumed by bombardment proponents that the future heavy bomber would exceed in size those then being flown in service operations. Since no funds were available, however, for experimental models during the fiscal year of 1926, only designs were bought from the Keystone Aircraft Corporation for a twin-engine monoplane bomber. These designs were to serve as a basis for specifications when procurement was authorized.[21]

The Chief of Air Corps, in March 1927, in an effort to speed up the still lagging development of an advanced type heavy bomber, outlined to the Chief of Materiel Division the various military characteristics needed to meet expanding tactical requirements. This included a minimum horizontal speed of 115 miles per hour at 10,000 feet and ability to maintain altitude on one engine; a minimum bomb load of 2000 pounds; increased defensive armament; two engines--either air or water-cooled; an operating radius of 400 miles; and a service ceiling of 15,000 feet.[22]

Bombardment airmen were disappointed in the performance of the new Keystone XB-1 and Curtiss XB-2 delivered for service test in 1928. In

design and general performance these biplane airplanes showed little advance over existing types. The XB-2, mounting two Curtiss 600 horsepower engines was later approved as the most suitable of the two models, but although superior in all-around flight characteristics of the Curtiss NBS-4, it failed to reach the concept of the "ideal bombardment plane" sought by such veteran bomber pilots as Maj. Hugh J. Knerr, Commanding the 2d Bombardment Group. He was strongly advocating at the time a twin-engine, all-metal monoplane, day bomber with a minimum high speed of 160 miles per hour, a ceiling of 18,000 feet without supercharger, and ability to carry a bomb load of not less than 2000 pounds.[23]

With the General Staff seeking to standardize bombardment aircraft by favoring an all-purpose model for day and night employment the bomber controversy, as outlined earlier in this study, was well underway. Consequently, Air Corps bombardment strength continued to decline, and, as a temporary expediency, a number of Curtiss B-2's were procured as tentative standard equipment. By the end of 1929, the total number of service bombers of all types was only 45.

In early 1930, an enlarged version of the Keystone LB-6, (light bomber) known as the B-3A, was adopted as a standard heavy bomber. The modified model mounted two 520 horsepower Pratt and Whitney direct-drive engines and incorporated a single rudder instead of a dual rudder, had an improved fuel system and various other structural refinements. Although bombardment proponents were still championing an all-metal multi-engine monoplane type, the only experiments conducted during this year were, as in the case of the B-3A, devoted to existing models. Geared engines were improved, new instrument panels designed, engine and shutter control improved, and tail wheels added to all equipment.[24]

One of the major problems confronting the Materiel Division, however, in connection with heavy bomber development, concerned the use of engine reduction gears, since they afforded a considerable increase in speed and rate of climb over the direct-drive type. Their use, of course, was accompanied by additional engineering problems. It was necessary, for example, to mount propellers of large diameter and, as a result, the engines had to be placed farther out on the wing to provide proper tip clearance between the blades. This introduced structual vibrations that were difficult to overcome.[25]

Despite the opposition of the 2d Bombardment Group to an all-purpose bomber, the Chief of Air Corps, in compliance with the desires of the General Staff, ordered the Materiel Division to proceed with the development of an experimental model for day operation. It was to be equipped with two direct-drive or geared-drive 600 horsepower liquid-cooled Curtiss engines. The minimum speed required was 170 miles per hour and a crew of three was to be carried, seated in tandem. It was also specified that the airplane attain a service ceiling of 16,000 feet with a normal bomb load of 1250 pounds. The aircraft industry was requested to submit several experimental types for inspection and performance test during the ensuing year.[26]

Apparently undismayed by this additional delay in achieving the desired goal of a long range, all-metal monoplane bomber, the "big ship" champions continued to urge its development. Meantime, many refinements in controls, instruments, brakes, engines, propellers, bombs, and other equipment, were assiduously sought. Newer and broader concepts of bombardment tactics and strategy were necessitating important changes in the Bombardment Directive regarding the role of the heavy bomber in national defense.[27]

Advanced Type Bombers: The year 1930 marks a turning point in general heavy bomber design. In response to an Air Corps circular design proposal in that year for an advanced type heavy bomber, six leading aircraft manufacturers in 1931 submitted experimental models for comparative performance test. This open design competition was the most important held to date and new aerodynamic improvements brought these models closer to the heretofore "radical" concepts of bombardment proponents.

First to arrive at Wright Field was the Ford XB906, although it was returned almost immediately for modification of its throttle controls. In general, this bomber resembled the Ford C-4A (Transport) and was equipped with three Pratt and Whitney 575 horsepower supercharged engines and carried a 2000 pound bomb load on an internal rack under the fuselage. The pilot's cabin was located to the rear of the center engine, with the bombardier's compartment below the pilot. The gunners' cockpits were placed fore and aft, the forward gunner just to the rear of the pilot. This model radically differed from standard bomber types and was expected to give exceptional performance at high altitude.[28] When the modified version was later tested, however, it was found to have unsatisfactory flight performance and the project was dropped.

Perhaps the most outstanding model submitted at the time was the Boeing XB901, an all-metal, low-wing monoplane with 600 horsepower Pratt and Whitney engines, and a rectractible landing gear. This airplane, later designated the B-9, showed a marked advance in structural design and general performance. Its high speed of 186 miles per hour at 6000 feet represented an average increase of 60 miles per hour in speed over any existing service bomber. The Materiel Division immediately placed this model under limited procurement for service testing.[29]

The Glenn L. Martin entry, the XB907, was still in the design stage. The original model was planned as a mid-wing, all-metal monoplane and was to be equipped with two Pratt and Whitney 550 horsepower geared radial engines. It had a retractable landing gear and an estimated bomb load of 1100 pounds. Thus, in general, the XB907 was similar to the Boeing model although it showed some improvement in structure, armament, and load carrying capacity.[30] In 1932, when performance tested as the XB-10, it was considered the fastest and most powerful heavy bomber of its class in the world. The improved model housed two 675 horsepower Wright engines and was equipped with a front gun turret. It attained a high speed of 207 miles per hour, had a service ceiling of 21,000 feet, and in over-all performance exceeded the latest specifications established by the Bombardment Board.[31]

Besides the above, there were several "dark horse" designs submitted in the competition. The Fokker XB-8 was similar to an observation type, the XO-27, previously submitted by this manufacturer, with the exception of a bomb rack of 1100 pound capacity. It was equipped with two Curtiss 600 horsepower liquid-cooled engines and was later performance tested upon installation of new cantilever-type tail surfaces. This model was eventually procured for dual bombardment and observation purposes.[32] The Douglas XB-7, an improved version of the XO-36, provided a similar bomb rack arrangement and was equipped with the same type engines. It was also later accepted for the same purpose as the XB-8.[33] Keystone's entry, a low-wing, all-metal monoplane, the XB-908, was dropped in the design stage when it became apparent that it could not compete with the other experimental models.[34]

During 1932, the Materiel Division strove to improve standard heavy bombardment equipment, as the monoplane gradually gained precedence over the biplane. The trend was distinctly toward all-metal construction, mid or low wing, monocoque fuselage, enclosed cockpits, retractable landing gear and streamlined wheels. The great increase in bomber speed in the early thirties was attributed to aerodynamic and structural refinements and the reduction of drag through the introduction of the retracting undercarriage rather than to any great increase in engine horsepower.[35]

In order to study the viewpoints of all commanders of Air Corps Stations on future bombardment development, Maj. Gen. Benjamin D. Foulois, Chief of Air Corps, in March 1933 distributed an extensive questionaire, requesting careful review, comments, and recommendations. Rapid changes in the bombardment field had necessitated a broad revision of the Directive on Bombardment and this method was chosen to "test" the reaction of active pilots to the latest models. Unexpected results were obtained. Many new and novel ideas in structural design were submitted, depicting the trend toward a large, four-engine heavy bomber, capable of flying hundreds of miles at high altitudes with a heavy bomb load, attacking enemy targets on land and sea, and returning to its base.[36]

Technological development in the Materiel Division also was definitely pointing to the procurement of larger bombardment airplanes than the YB-12 (a modified B-10). This change was motivated largely by the discovery that increased aerodynamic efficiency could be achieved with increased size--earlier believed a fallacy. Gradual reduction of drag by eliminating structural protuberances had also become an appreciable factor toward obtaining improved flight performance. Thus, although the "big bomber" trend would result in greatly increased cost per unit, it was evident that the attendant superior performance of the large airplane would do much to offset this factor.

Announcement of the above policy by the Materiel Division and the aircraft industry not only completely changed the accepted methods of constructing bombers, but tremendously influenced engine and propeller design. Whereas in the twenties, increased horsepower per unit had been a primary objective in engine design, more radical changes were necessary in the early thirties, affecting not only detail design but cylinder arrangement, over-all form, shape, materials, and methods of construction, in order to conform to the streamlined wings of the latest bomber models. Propeller research had resulted in the development of the controllable pitch and the constant-speed types with hollow steel blades. The tactical need for increased speed and high altitude performance had also presented the problem of low altitude performance, the solution to which was found in the construction of the above types of propellers.

The development of the all-metal monoplane bomber was in answer to the persistent demand of bombardment proponents for increased speed, range, and carrying capacity. Its success had been attained primarily by increasing the number of engines and by providing greater horsepower. Speed, however, had imposed new aerodynamic problems--cleanness of structure--that required a complete change in the earlier conception of a large bomber. Box spars, multi-spar wings, and smooth metal surfaces were now essential to advanced aircraft construction. Speed also imposed the necessity for high wing loading, with its attendant increased stresses in structure, as well as the demand for flaps and high lift devices in order to obtain reasonable performance for take-off and landing.

These were only the major problems confronting the Materiel Division; there were innumerable detailed problems which made for the ultimate success

or failure of the heavy bomber. And, despite budgetary limitations which reflected the War Department attitude toward the development of large bombardment airplanes, intensive research had been conducted in collaboration with interested aircraft manufacturers. Indeed, preliminary investigations were underway late in 1933 for an ultra long range multi-engine monoplane bomber. Boeing and Martin had submitted preliminary designs and engineering data, and after careful study of this material, the Division had negotiated contracts in the following year for additional technical information, tests, wind tunnel models, and mock-ups.[37]

The Air Corps in 1934 wanted a heavy bomber with a speed comparable to the latest pursuit airplane of foreign powers and with strong fire power to fight off concentrated enemy air attacks. The ideal airplane was to carry a bomb load of many tons, fly above 24,000 feet, and have a range that would enable it to span the continent in a single flight at a speed approaching 250 miles per hour. It should also be capable of carrying its striking power far out to sea to intercept and destroy any enemy attempting to invade American shores.[38]

The B-17 "Flying Fortress": To build such an airplane in that year was a vast undertaking and challenged the best aeronautical engineering thought in America. Although the design competition proposal distributed by the Air Corps in 1933 had not specified two-engines (it read "multi-engine"), all but one manufacturer, perhaps in view of War Department economy policies, had assumed that only a highly superior twin-engine model of standard design was desired. Boeing engineers, however, noted the loop-hole allowed in the term "multi-engine" and launched as a private venture the pioneering development of a four-engine superbomber of radical

design. Only twelve months were allowed in the proposal for the creation and the construction of an experimental model.

In September 1934, the XB-17 emerged as a workable design. Many problems still had to be solved since no bomber of such revolutionary structure had yet been produced in the United States. Numerous improvements in design were included which were more or less a composite of the best features of bombardment airplanes evolved since the Martin MB-2. To reduce air resistance, bombs were to be carried internally; pilot and crew members were to be housed inside the fuselage in heated, soundproofed quarters; additional machine guns were to be installed to fire from enclosures in the fuselage; versatility of operation would be achieved by the new Hamilton constant-speed propellers; tabs were developed for the rudder and elevators to assure easier trim control; and every protruding surface was to be eliminated as far as possible to provide an aerodynamically clean airplane.[39]

It was in July 1935 that the Boeing Seattle plant turned out the XB-17 which successfully made its maiden flight from Seattle to Dayton the same month. The preliminary performance of this bomber, the largest monoplane ever constructed for the Air Corps up to that time, exceeded even the expectations of its designers. On the following month, the XB-17 was flown from Seattle to Wright Field for entry in the open design competition with twin-engine models offered by Martin and Douglas. On that flight it covered the 2100 miles non-stop at an average speed of 232 miles per hour. During later performance tests, however, the XB-17 unfortunately crashed in flames* and was practically demolished.[40] Nevertheless,

* Official investigations exonerated the bomber from mechanical and structural failure.

Air Corps bombardment pilots had already been "sold" on its exceptional performance and a contract was let for thirteen models to be delivered in the fiscal year of 1936.[41]

In construction, the succeeding service test model, the YIB-17, was little changed from the original. Its fuselage was of semi-monocoque type, consisting of longitudinal and circumferential stiffeners, bulkheads, and smooth outside metal skin. The mid-wing had a span of 103 feet and 9 inches in length, the over-all height was 18 feet and 3 inches, and its gross weight was 34,873 pounds.[42] For the first time on any Army bomber, the landing gear (fully retractable along with tail wheel) was equipped with air brakes--a special Boeing development.

The big bomber housed four Wright 850 horsepower engines mounting three-bladed constant speed propellers. It had a high speed of 256 miles per hour at 14,000 feet, a service ceiling of 30,600 feet, carried a normal bomb load of 2500 pounds for 2260 miles at operating speed, and possessed a maximum endurance of 10.4 hours in the air.[43] This model was also capable of carrying a maximum bomb load of 5000 pounds for 1700 miles at a cruising speed of 228 miles per hour.[44]

Many new armament features were also incorporated. There were five gun positions: one in the nose; one above and one below the fuselage, in line with the trailing edge of the wing; and one on each side of the fuselage, midway between the wing and the tail. The four last mentioned were in the form of streamlined "blisters", designed to offer the least possible air resistance.[45]

While the first XB-17 was being performance tested, the Materiel Division was encountering numerous maintenance difficulties with the

Martin B-10, B-12, and B-12A. This was principally attributed to inadequate service testing before accelerated production was begun and the models placed in service.[46]

Turbo-superchargers were being developed during 1935 for the Martin B-10A. Although cylinder cooling presented a difficult problem for the Materiel Division engineers and engine manufacturers, some success was achieved after extensive tests were made. It was apparent that further research and experimentation was necessary to utilize this means of improving the altitude performance of existing service models.[47] At the same time, the Martin B-10B, a modification of the basic B-10 and B-12 types, was under development. Many changes were incorporated, such as higher critical altitude engines, wing flaps, controllable pitch propellers, larger wheels (45 inch), provision for an automatic pilot, an additional radio, and radio direction finding equipment. The first model had been delivered to Wright Field in June 1935 for inspection and tests, but was returned to the contractor for correction of faulty flight characteristics.[48]

Convinced that the superior performing B-17 had opened the way for establishing a strong offensive air power, Air Corps and GHQ Air Force officers had been championing the experimental development and construction of even larger and more powerful types. The twin-engine bomber, they believed, should be reclassified as a medium type for long range reconnaissance and general bombing operations.[49] In fact, the Commanding General of the GHQ Air Force, later on, recommended the exclusive development of the four-engine model to perform all long range missions.[50]

The War Department attitude, however, was still unfavorable toward the procurement of four-engine bombers larger than the B-17 since the

General Staff had concluded that no tactical or strategical requirement existed for a bomber with a range exceeding 3500 miles.[51] Although the Air Corps, prior to the B-17 development, had been permitted to contract with Boeing for one Project A ultra long range four-engine bomber for experimental purposes, the Project D design, which planned an even larger model with a greater range, was being held in abeyance by the Secretary of War despite an option negotiated with the Douglas Aircraft Company in December 1935. It was not until September 1936 that this ban was lifted and authority given to construct the experimental model.[52]

Meanwhile the A,B,C, and D models of the B-17 were being successively developed. Designed for the most part as defensive aircraft they nevertheless laid the foundations for high altitude combat bombing by employing turbo-supercharged engines. This was still the standard B-17 model at the time war began in Europe.

In 1938, the Air Corps conducted a study of the development of foreign heavy bombers, after the Chief of Air Corps expressed great concern to the Chief of Materiel Division over the unusual progress being made abroad along this line. A complete analysis was requested with specific reasons why the performance of the foreign models, in some instances, exceeded those of the Air Corps.

Comparison was made between the B-17 and the latest German four-engine Junkers 89 and the Russian four-engine TB-6, which were reported by military intelligence to have superior altitude and speed performance. These advantages were attributed to sacrifice of crew comfort and the elimination of gun protuberances to increase the speed. Special engines producing more than normal rated power and high octane fuels were also contributing factors

in their improved performance. The critical altitude of the foreign models, however, was not as efficient as that of the B-17, since the turbo-supercharger installation mentioned above had boosted its operational altitude to 20,000 feet. This surpassed the German and Russian bombers by approximately 6000 feet. The Chief of Air Corps, however, stressed the fact that the latest military characteristics of American bombers under experimental development fell short of the performance figures acquired by military attache's for foreign experimental bombers. Some were reputed to possess high speeds of 290 miles per hour at 15,000 feet. He believed that crew comfort and convenience, although desirable for increased efficiency, should be subordinated in future American heavy bombers unless performance comparable to foreign models could be retained.

Foreign powers were fast accumulating data more advanced than that possessed by the Materiel Division on such matters as interference effects (wing-fuselage-landing gear, wing-engine-propeller, gun emplacements, blisters, various arrangements of tail surfaces, etc); surface smoothness and finishes; engine compactness and design forms that blended in aerodynamically with the complete airplane; and integral superchargers for intermediate altitudes. It was probable that, in addition to the acquisition of superior basic information, foreign powers had been able to reduce theory to practice by the construction of large numbers of experimental prototypes.[54]

To expedite the experimental development of a bomber to serve as companion to the B-17, capable of exceeding the performance of experimental foreign aircraft in the same class, the Materiel Division during 1938 encouraged aircraft manufacturers to develop preliminary designs for review

by Division engineers. During that year, however, Congress slashed Army appropriations which had included increased funds for the heavy bomber development program.

The Chief of Air Corps, in an effort to push the lagging plans for a long-range running mate to the B-17, called in Consolidated Aircraft officials for a conference at Wright Field in January 1939.[55] They were asked to produce a four-engine bomber with a speed in excess of 300 miles per hour and a ceiling of 35,000 feet, minimum cruising speed of 220 miles per hour, and an operating range of 3000 miles.

The B-24: In March 1939, the Materiel Division was presented with preliminary designs and engineering data for the XB-24, and, at the end of the month representatives of the Air Corps signed a contract with Consolidated for the prototype of the new model to be produced in nine months.[56] In December, three months after war broke out in Europe, the XB-24 was successfully flown at Lindberg Field, San Diego. In general design, it differed greatly from the B-17. Its 110 foot wing was a radical departure in airfoil types then in use, having a narrow, straight tapered, high aspect ratio design, symmetrical in appearance. Other new features included hydraulically operated wing flaps and bomb bay doors as well as power brakes.

The XB-24 was the first American heavy bomber to operate with a retractable tricycle landing gear, and unlike the B-17, its tail assembly had two vertical fins and rudders. The Hamilton standard three-bladed, full-feathering hydromatic propellers mounted on Pratt and Whitney 1200 horsepower engines were also introduced on this model. Its service ceiling was estimated to be 31,500 feet, its gross weight was approximately 56,000 pounds, and it could carry a maximum bomb load of 8960 pounds.[57]

The probable future development of heavy bombers was discussed by Col. Carl Spaatz in a lecture before a group of officers concerning the Air Corps Expansion Program. He declared that the immediate development of airpower built around the B-17 and the B-24 was imperative. The new XB-24, Colonel Spaatz considered, was a greatly needed Air Corps addition, with its high speed exceeding 300 miles per hour at 15,000 feet, long range of 5000 miles at economical fuel consumption, and a normal 2500 pound bomb load. With improved powerplant installations, the speed of this model could possibly be stepped up to 400 miles per hour. He pictured, for the near future, large bombers, capable of a 5000 mile range at 200 miles per hour with a bomb load of 4000 pounds.[58]

In the months that followed Germany's conquest of western Europe, one of the major problems confronting Air Corps leaders concerned the number of heavy bombers needed to insure adequate national defense. Since the President had authorized the production of 50,000 airplanes, it was necessary to provide a breakdown of types in order to assure a balanced development program.

Early in the fall of 1940, the Materiel Division let contracts to Boeing for 500 B-17's and to Consolidated for 500 B-24's--two per cent of the proposed 50,000. This marked the opening of the Air Corps heavy bomber production program.

Shortly after General Arnold's return from a mission to England in the Spring of 1941, President Roosevelt announced that the production of heavy bombers would be stepped up to 500 per month, definitely indicating that this type of aircraft was regarded by both military and government leaders as the primary offensive weapon of air warfare. After Pearl Harbor, with the envisioned need of thousands of heavy

bombers, especially for the projected long-ranged European campaign, it was announced that the production schedule was to be doubled.

The main problems confronting the Materiel Command were the speeding up production schedules through the construction of new aircraft plants and the retooling and utilization of existing plant facilities. In the critical period that followed, thousands of man-hours were saved in preliminary work by pooling engineering staffs, blueprints, tooling setups, and so on. In the process of approaching something resembling mass production in the ensuing months of 1942, arrangements were made to provide for interchangeability of parts to facilitate servicing at the fronts; new assembly-line techniques, highly intricate machine tools, as well as hitherto untried processes, were also developed, all resulting in an amazing shrinkage of man-hours from over 100,000 per four-engine bomber to approximately 30,000. By the end of that year, the heavy bomber production program had shifted into second gear and was gradually accelerating its speed.

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Chapter V

MATERIEL DIVISION DEVELOPMENT OF THE VERY HEAVY BOMBER

When the Project A (XB-15) model was delivered to Wright Field in December 1937 it was already considered by Air Corps and GHQ Air Force bomber proponents as the intermediate type between the B-17 and the Project D (XB-19) very heavy model. The new XB-15 actually dwarfed the B-17. Carrying a gross weight of 35 tons, this airplane was twice as heavy, 20 feet longer, and its wing span was 45 feet wider.[1] In publicity announcing the XB-15, the Air Corps declared it now had examples of three bomber types—the twin-engine Martin, representing the medium weight carrier; the B-17 as the compromise heavy weight carrier, and the new XB-15 as the maximum heavy weight carrier. Service employment would afford the Air Corps an opportunity to fully compare all three, with a view to determining the value of each type from an engineering, tactical, and operating standpoint.[2]

In general design and construction, the XB-15 closely patterned the B-17. It was an all-metal, mid-wing type monoplane, equipped with four 1000 horsepower Pratt and Whitney twin-row engines. Many new safety devices were incorporated, including improved radio direction finding equipment, automatic pilot, de-icing installations, fire protection apparatus, wing flaps, complete heating and ventilating system, dual-wheeled retractable landing gear, and air brakes. The XB-15 was also the first airplane to provide complete living and sleeping accommodations

for a crew of ten.

Defensive armament consisted of six enclosed machine gun positions, a nose turret, a top turret, and four streamlined blisters, one on each side of the fuselage and two on the bottom. It had a high speed of 200 miles per hour and a maximum ferrying range of 5050 miles. Carrying a normal bomb load of 2500 pounds, however, its operating speed was reduced to only 145 miles per hour. On a short haul it was capable of a 12,000 pound bomb capacity.

Although this giant bomber was generally considered a successful type, it was the only one procured by the Materiel Division. Its slow speed, primarily resulting from insufficient horsepower, prohibited it from becoming at that time an effective combat airplane. The design, in this case, had far surpassed the performance of the highest horsepower engines available.[3]

Although the construction of large bombers had facilitated studies in the development of new engine designs, improved cooling methods, fuel injection, and supercharging, it was still a moot question as to whether engines with horsepowers in excess of 1200 in single units were more advantageous than multiple units of lower horsepower. It had been the Air Corps stand that engines of 1000 to 2000 horsepower were more normal and logical developments than very high horsepower single units in the 3000 and 4000 class, which might be too great and sudden a technical advance to insure sound and superior results. In the past, the large units had introduced vibration and propeller problems which were being subjected to concurrent research and development. Consequently, in the experimental construction of the XB-15, the largest engine that had been

available in the middle thirties was rated at 1000 horsepower. The Materiel Division, rather than risk failure of the project by redesigning the bomber around one of the several proposed experimental engines of higher horsepower, requested installation of a service tested type.

The engine problem was but one of many experimental "firsts" confronting the Materiel Division and the aircraft manufacturer. Since the XB-15 was approximately twice the size of any airplane ever flown, the structural design, accessory equipment such as propellers, superchargers, landing gears, control surfaces, and electrical power to operate the many mechanisms, all required exhaustive research and experimentation.

One of the most difficult problems confronting the designers and engineers was the question of controllability in flight. Although during the thirties many new and improved developments along these lines were in progress which appeared desirable to incorporate in the XB-15 project, the Division decided not to include too many untried devices. Considerable progress had been made with the turbo-supercharger, but it was excluded from the project because it still presented some aerodynamic, engine, and propeller problems. A tricycle landing gear, which had also been considered for the first model, was finally rejected in favor of the more conventional type.[4] The Division knew that the future of the very large heavy bomber was at stake and refrained from jeopardizing the proposed development of the XB-19 by producing the XB-15 as a possible failure.

The Chief of Air Corps, after the extensive performance testing of the XB-15, was of the opinion that this giant bomber had proven successful

both aerodynamically and structurally. He favored modernizing the model by producing a modified type to be redesignated the YB-20, which would incorporate the newest technical developments of the Materiel Division as of the mid-summer of 1938. These improvements included a retractable tricycle landing gear, higher horsepower engines, improved armament, and simplified electrical installations. The first two of these modifications were to increase the top speed from 200 miles per hour to approximately 240 miles per hour, resulting in improved protection from fast enemy pursuit attack.[5] The Assistant Secretary of War later disapproved the recommendation and the project was subsequently abandoned.

Despite limited budgets and continued opposition in the War Department, the Materiel Division intensified its study of an ultra long-range, substratosphere bomber in the Project D class. Since the XB-19 project was already underway,* consideration was being given to providing an even superior model, utilizing the successful application of the pressure cabin principle. The proposed bomber was to have an approximate ceiling of 40,000 feet with a pressure equivalent of 8000 feet; an estimated speed of 350 miles per hour; four 2000 horsepower turbo-supercharged engines; a minimum bomb load of 2500 pounds; a minimum range of 4000 miles, and powerful armament.[6] The engineering experience acquired in the development of the XB-15 was being applied to the XB-19 project and this in turn was guiding research into the manifold problems of the sub-stratosphere bomber. Early designs were eventually transformed into the very heavy and powerful B-29 and B-32.

* See Chap. II above.

The Project D Bomber (XB-19): The construction of the XB-19 was also posing many complex problems of structure and equipment. Like its predecessor, it was an all-metal monoplane, but incorporated a retractable tricycle landing gear. Its wing span was 212 feet, its length 132 feet, and its overall height 42 feet. Equipped with four 2000 horsepower Wright Duplex-Cyclone turbo-supercharged engines, it was expected to attain a high speed of 210 miles per hour at 12,000 feet, and reach a maximum overloaded range of 7750 miles. Its gross weight was to be 160,000 pounds, and although it would carry a normal bomb load of 2500 pounds this could be increased to an approximate total of 37,080 pounds on a short haul of 2000 miles. The service ceiling of this giant monoplane was estimated to be 22,200 feet. It also would be capable of carrying a crew of ten and provided sleeping accomodations for eight. For defensive armament, the XB-19 would carry seven machine guns in power-driven turrets in the nose and tail and above and below the fuselage.[7]

The culmination of three and one-half years of planning and engineering of the Division, in conjunction with the Douglas Aircraft Company, the XB-19 was successfully test flown in June 1941. Certain details used in its construction had already been adopted for experimental airplanes then under construction and the primary purpose for its production was to provide a source of valuable laboratory information which would be vital in the development of future aircraft of very large dimensions.[8]

Some of the immediate problems to be pursued at that time by the Materiel Division in the XB-19 "flying laboratory" were the general flight characteristics of very large airplanes, control forces, vibration

and flutter, stability on all axes, fuel consumption with range and load, inspection maintenance and repair while in flight, pilot and crew fatigue, anoxia and anoxemia (oxygen want) over 12,000 feet, and other important investigations for possible application to the eventual operation of the XB-29 and XB-32. From the standpoint of production, the XB-19 also was to serve as a "yardstick" on labor and materiel problems in connection with design, engineering and construction.[9]

Predicated upon the valuable data that had been and was being accumulated in the development of large and more conventional heavy bombers, research had turned in the late thirties to the flying wing type of airplane for superior speed and altitude performance. In this connection, a special conference was held at Wright Field in January 1938 to consider a pressure cabin design with many novel features proposed by the Consolidated Aircraft Corporation.

An experimental all-metal model could be constructed with either a two-engine or four-engine installation, with the engines totally inclosed within the wing. It would have a retractable tricycle landing gear, strong fire power, an estimated range of 8000 miles without bomb load, and a high speed of approximately 321 miles per hour. Although the reviewing board of officers declined to recommend its acceptance at the time, additional data was requested for further consideration. Some skepticism was professed over the ultimate practicability of such a design although the eventual construction of an experimental model was favored,[10] and it was not until August 1941 that a contract was negotiated for its preliminary development.[11]

The B-29: In response to the Air Corps' late 1939 request for a 4000 mile bomber, Boeing had submitted drawings of design 341, an 85,700 pound airplane. In the meantime, however, realization of the new needs of air power were obtained from the European War Theater. The American superbomber would need armor plate, and greater fire power than had originally been visualized. In the summer of 1940, therefore, Boeing produced design 345, a still larger aircraft with a gross weight between 100,000 and 120,000 pounds. Approved by a board of officers headed by Col. O. P. Echols, Chief, Materiel Command this was to be the design of the XB-29.

The major engineering problem to be faced was the building of an airplane weighing almost twice as much as the B-17, and flying it 30 per cent faster, while keeping the increased power expenditure to a minimum. The new Wright 2200 horsepower engines made 8800 horsepower available to the B-29 at take-off, compared to the 4800 horsepower in the B-17. Even this increase in power, however, was not sufficient to drive a B-17 type airplane at twice the weight and 130 per cent of the speed of the B-17. Since the available power was limited, Boeing engineers solved the problem by producing an airplane that was aerodynamically clean enough to produce the same air resistance as a B-17 even though it doubled the weight of that airplane.[12]

Wind tunnel tests with models of the XB-29 were conducted by the University of Washington, California Institute of Technology, and the NACA. These tests so impressed the Air Corps that on 24 August 1940 Boeing was authorized to build three full size XB-29's. The first of these was flight tested at Seattle on 21 September 1941.[13]

In dimensions, the new VHB had a wing span of 141 feet and 3 inches, a length of 99 feet and an overall height of 27 feet and 9 inches. The four Wright R-3350-23 eighteen cylinder engines were mounted by four bladed Hamilton constant speed, full-feathering propellers, 16 feet and 7 inches in diameter, equipped with 35/100th reduction gears to keep top speed below the velocity of sound. At full military power the B-29's maximum speed was rated at 372 miles per hour at 30,000 feet with its ferrying range set at 4400 miles, and its operating range (with normal bomb load of 4000 pounds) 3300 miles.

For defensive armament the B-29 was equipped with nonretractable turrets mounting ten .50 caliber machine guns and one 20 mm. cannon. These turrets (two upper, two lower, and cannon-gun combination tail) were all remotely controlled by a central fire control system with sighting stations for the bombardier in the nose, two side gunners and a top gunner in the waist and a tail-gunner.

Other outstanding features of the B-29 were: pressurized compartments; a new type wing that produced maximum aerodynamic efficiency; an improved flap arrangement that limited take-off and landing runs to correspond to those of the B-17 and B-24 by increasing the total wing area 19 per cent when extended; a dual wheel retractable tricycle landing gear; flush-riveting and butt-jointing to reduce drag (the landing gear lowered contributed approximately 50 per cent of the resistance); and extensive radio and radar equipment including liaison set, radio compass, marker beacon, glide path receiver, localizer receiver, IFF transpondor, emergency rescue transmitter, blind bombing radar, Raven radio countermeasures, and static dischargers.

The cumulative effect of so many advances in aeronautical design and equipment produced more than the normal quota of "bugs" attendant to new plane development. To nullify torque action, for example, counter-rotating propellers were originally considered. This, however, necessitated further research and in the urgency of the moment a new rudder design was developed that solved the problem. Ignition systems, auxiliary motor generators, fuel guages, bombing equipment, control cable systems, and fuel cell leakage were among the many items to receive minute study, and often drastic change.

The greatest of these problems, however, was the R-3350 engine. First tested in early 1937, by November 1943 some 2000 engineering changes had been made in the engine, approximately 500 of which required changes in tooling.[14] Col. A. H. Johnson of the Production Division at Wright Field sounded the keynote of the critical situation in a letter:[15]

> We are now experiencing one of the worse /sic/ epidemics of engine troubles in airplanes with Wright Aeronautical engines that we have ever had . . . .
>
> It will be impossible for me to over-emphasize the seriousness of the situation. If the conditions exist for another week or ten days, I am sure that the morale of the operating units will be so shot that it would be difficult to get them to properly fly the airplanes.

About a month later conditions remained unchanged. In fact the R-3350 was declared "unsatisfactory for service use due to several major weaknesses /which were/ likely to require five to six months of intensive well-directed effort to correct . . . ."[16] Consequently, on 23 April 1943 an R-3350 Engine Committee was established at Wright Field to expedite the modification and maintenance of the engine throughout the gigantic

B-29 program.[17]

Meanwhile flight testing of the B-29 had been proceeding throughout early 1943, until on No. 2 test airplane an engine caught fire during test flight and the huge bomber crashed. This accident naturally retarded the development program, since every possible step had to be taken to eliminate fire hazards. Consequently all flight operations were suspended and it was not until September 1943 that the air tests were resumed.[18]

While production models of the already greatly modified B-29 were rolling off the line, the 58th Bombardment Wing, organized in June 1943, was conducting accelerated tests of this bomber and formulating training policy for achievement of its prime mission—to strike devastating blows against the Japanese Empire.

The first step toward accomplishing this ultimate goal was begun on 4 April 1944 when the new global air force, the Twentieth, was activated at Washington, D. C.[19]

> It is directly under the Joint Chiefs of Staff and has General Arnold himself as Commanding General. Brigadier General K. B. Wolfe, Commanding General of the XX Bomber Command, undertook to submit the B-29's to simulated combat testing as soon as they came off the production line, and at the same time as transition training was in progress and the Twentieth Air Force organization was being developed. This plan was designed to make the B-29 ready for combat with as little delay as was possible.

The Superfortress began its activities against Japanese installations on 6 June 1944, less than three years after the initial flight testing of the XB-29, with a "shake-down" raid on Bangkok. Seventy-eight airplanes participated in this raid and dropped 369 tons of high explosive and incendiary bombs from altitudes of 17,000 to 27,000 feet. Nine days later the real air offensive against the Japanese Empire began with the accomplishment of "Mission Number One," a strike by 60 Superfortresses

against steel mills and shipping at Yawata in Japan proper. In the months that followed, B-29's from the XX Bomber Command bases in China and India struck at the farthest corners of the Japanese Empire—Nagasaki, Palembang, Singapore, Mukden, Rangoon, Bangkok, and Tokyo, which by November 1944 was being raided regularly by the XXI Bomber Command based at Isley Field, Saipan.[20]

The B-32: After the Air Corps' "Request for Data" of 29 January 1940 the Consolidated-Vultee design for the B-32 was immediately approved and a mock-up constructed and inspected by 17 April 1941. Following these inspections three airplanes were procured and to accelerate development the first was flown, in a stripped condition, on 7 September 1942.

At the inception of the VHB program, the B-32 was regarded as an insurance measure against the possible failure of the B-29,[21] and, it was assumed, would engage in strategic operations similar to that planned for the B-29.[22]

The XB-32, like its running mate, was of conventional design, an all-metal, high wing monoplane with a semi-monocoque fuselage, retractable tricycle landing gear, and was powered by four Wright R 3350-23 engines, each developing 2200 horsepower for take-off, and mounting four-bladed Hamilton Standard reversible-pitch propellers. Maximum gross weight was 123,250 pounds which included a maximum bomb capacity of 20,000 pounds for short range operations. Normally, this giant airplane was to carry 5600 pounds of bombs for a distance of 5625 miles at an operating altitude of 25,000 feet and was adaptable for carrying single 11,000 or 22,000 pound bombs. Its ferrying range was set at 4400, and at full military power and combat weight (100,000 pounds) its high speed was 357 miles

per hour at 30,000 feet, which was comparable to B-29 performance. Its defensive armament consisted of ten .50 caliber machine guns, two in a nose turret, two each in front and rear top turrets, two in a lower ball and two in the tail turret, all remotely controlled from three computer stations.

After the first model (twin tail) made its initial flight in September 1942 in a stripped down condition, subsequent status reports indicated that this model and the second model had developed an unsatisfactory aerodynamic condition around the inboard nacelles which was adversely affecting the empennage, inboard nacelles, and ailerons. The third model, equipped with an improved design single tail, showed a marked improvement in directional control and rudder effectiveness, although some investigatory work was still necessary.[23]

Throughout 1943 there were many major changes in the XB-32 as it evolved into the B-32 and most of these were a result of lessons learned in combat operations of the B-17 and B-24. A single vertical tail was substituted for the original twin tails; pressurization was eliminated and locally operated turrets installed*; the power plant nacelles were redesigned; heated wing de-icing was introduced; fuel and oil system improved; all-electric bomb-release system added as well as

* In this connection it is interesting to note the following statement by Capt. W. M. Stiger of the Weapons Section, AFPGC: "It is the opinion of the Weapons Section of the Proving Ground Command's Proof Division that the success of the B-29 in defending herself in combat is attributable to the inherent superiority of the B-29 as an airplane, in speed, altitude, and maneuverability, and not to the reliability of the fire control system." (Interview by Hist. Officer, AFPGC, with Capt. W. M. Stiger, Proj. Officer, Weap. Sect., PD, 10 Mar. 1945, in HB File 000.71, Interviews, cited in Hist. AAFPGC, part XII, p. 50.)

M-series bombsight and automatic flight control equipment; vision, especially bombardier's, improved; fire-power increased; maintenance simplified through the use of standard parts; and emergency exits improved.[24]

The original intention of the Army Air Forces was to put the B-32 into combat operations by the summer of 1945, as a part of the "48 Very Heavy Group Program." But it was August, 1944 before the first Army test flight of a production B-32 was accomplished--and then it was damned with faint praise.[25] By November 1944 the estimated availability of B-32 airplanes was so meager and the production so uncertain that it was thought inadvisable to plan the use of the aircraft during 1945.[26] In actuality the B-32 was never used in the European theater and was used in the Pacific theater only for a brief time on a very small scale after hostilities had ceased in Europe.

Finally, on 12 October 1945, the disappointing B-32 program was officially terminated, its overall failure chalked up to "the exigencies of war, when 'too much' is more greatly to be desired than 'too little'."[27]

New Experimental Bomber Designs: The moot question of studying the development of ultra long-range heavy bombers superior to the B-29 and B-32 was brought to the attention of the Materiel Command by Brig. Gen. E. L. Eubank, Director of Bombardment, in the latter part of September. It was pointed out that the Air Forces might someday be required to produce heavy bombers capable of conducting missions non-stop from bases within the United States to foreign objectives. This would necessitate a range of 17,000 to 20,000 miles under optimum conditions with an operating radii of 8,000 to 7,000 miles. Such airplanes, if possible, should be

able to carry a 25,000 pound minimum bomb load for the full range.[28]

In August 1943, North American and Consolidated presented very heavy bomber designs to the Materiel Command for engineering evaluation. The latter's design was the most interesting since it was a new version of a flying wing (tailless) airplane. It was believed by Materiel Command engineers that if the wing loading could be kept high and a high center of lift could be obtained for the landing condition, this airplane would have a definite advantage over the XB-35.* Consolidated proposed to provide these features by incorporating a retractable horizontal tail surface. This pressure-cabin flying wing was designed for four tractor engines which were to be turbo supercharged, completely submerged in the wing, and connected by extension shafts to two dual counter-rotating propellers. Each engine would drive its own propellers and they could be independently feathered. Leakproof integral fuel cells would provide 7000 gallons of fuel and removable bomb bay tanks would carry 6000 gallons.

Defensive armament would consist of a nose turret (four .50 caliber machine guns), an identical tail turret, an upper aft turret (two 37 mm cannon), and a lower aft turret (two 37 mm cannon), all of which were to be locally operated and pressurized.

The principal unconventional features of the Consolidated tailless design were the large increase in lift-drag ratio; the use of full span flaps which allowed a high lift coefficient; the longitudinal trim which was obtained at the stalling point by extendable trailing and leading edge trim surfaces, and wing tip leading edge slots. Performance data

* See Chap. III above.

indicated a high speed of 374 miles per hour at 30,000 feet and a war emergency power of 407 miles per hour at the same altitude. Service ceiling was estimated to be 43,000 feet.

Carrying a normal bomb load of 5000 pounds, the Consolidated flying wing was expected to attain a maximum range of 7500 miles at an average operating speed of 240 miles per hour with a crew of nine. For a short range of 3500 miles, a maximum bomb load of 40,000 pounds (internal) could be carried at the same speed. Gross weight (war maximum) would be approximately 180,000 pounds.

The North American very heavy bomber design, although showing an excellent armament arrangement, did not appear to offer any definite advantages over the B-29 and B-32, when considered from the standpoint of a two and a half year development interval from the date of initiating an experimental project. It was believed that by adding more horsepower to the foregoing airplanes, plus two years of intensive development, based on combat experience, their performance would equal, if not better, the proposed North American model.[29]

As the engineering development was proceeding on the long-range Northrop XB-35 and the Consolidated XB-36 in 1943 and 1944, the Materiel Command and the aircraft manufacturers were encountering various retarding conditions and factors. The engineering completion date of 1 March 1944 had been set for the XB-35, but such problems as aerodynamic design of elevator and rudder control surfaces, hydraulic boost control, and a new electrical system, had postponed this date to August 1945. Additional difficulties, such as inability to secure engineers and technical personnel had also contributed to the delay in providing the first experimental model.

Bombardment experts, however, considered the XB-35 such an advance in bomber design that it was deemed advisable to continue its development, despite the eighteen months extension of the contract.[30] A flying model (.3 scale), designated the N-9M, had been successfully flown and was found generally satisfactory in performance, except that some difficulty was encountered in directional control and elevator control at low speeds.[31]

In design, the XB-35 was a full flying wing (tailless) very heavy bomber of all metal construction, to be powered with four XR-4360-7 submerged engines driving dual rotation pusher propellers through long drive shafts, each developing 3000 horsepower for take-off at 2700 r.p.m. With a wing-span of 172 feet, a length of 53 feet, and an overall height of 19 feet and 3 inches, it had a guaranteed high speed of 386 miles per hour at 35,000 feet and military power, and a range of 4600 miles at 245 miles per hour carrying a bomb load of 10,000 pounds. Its service ceiling was estimated to be 40,000 feet at .3 range, and the design gross weight was 155,000 pounds with a useful load of 71,330 pounds. The maximum bomb load of the full size XB-35 was to be 32,000 pounds in combinations of 4000-, 2000-, 1000-, and 500-pound bombs, with 24,000 pounds carried internally and 8000 pounds externally. If made up entirely of thirty-two 1600 pound armor piercing bombs the above maximum bomb load could be increased to 51,200 pounds.

Defensive armament was to consist of twenty .50 caliber machine guns mounted in remotely controlled turrets as follows: four in a flexible tail turret, two each in an upper and lower wing turret, and four each in an upper and lower cabin turret.

Other features included pressurized crew compartments; retractable tricycle landing gear with dual main wheels and single nose wheel; four eight-bladed, full feathering constant speed propellers; engine turbo superchargers installed in a plenum chamber; and other novel developments.

Action was initiated to procure the first XB-35 in July 1941 and the contract was approved by Secretary of War Stimson in October of that year. The project was set up in three phases as follows: (1) engineering data for evaluation of design and release for development; (2) tests of models and reports of contractor's flying mock-up; and (3) construction and test of .3 or .4 scale flying mock-up. Delivery of the first model was to be accomplished in 360 days from the date of contract. Along with this negotiations for one airplane had been arranged in August 1941 and the contract was approved by the Secretary of War in November. Later this contract was amended to provide for an additional model in case the first one was damaged or demolished in an accident. A mock-up of the initial model was inspected in July 1942, and the estimated flight date for the reduced scale flying wing was set for December of that year.

The N-9M-No. 1 Model later crashed on its 45th flight after 22 hours and 32 minutes of testing, but two other models had been ordered shortly before this accident in order to avoid any undue delays in completing experimental tests. In late 1943, a change order was made to the contract to allow production of one N-9M-B model which would accurately represent the full size XB-35, including all modifications in design.[32]

Although the hoped-for range and speed of the XB-35 were probably not going to be realized, it was felt that the airplane might still be outstanding in performance. In fact in a memorandum of 10 January 1944

Brigadier General F. O. Carroll, Chief of the Engineering Division at Wright Field recommended that the "experimental and production program continue in their /sic/ present status, e.i./sic/, pursue vigorously," since "present performance expectations represent a great advancement making project highly desirable from a development standpoint."[33]

By the end of 1944 it was considered that the over-all progress on the XB-35 was limited by the rapidity with which solutions could be determined for the individual unconventional elements which made up the unconventional aircraft. None of the existing problems were considered impossible of solution. In fact, in connection with the future development of the B-35 type airplane AAF Headquarters showed interest in obtaining proposals for installation of jet engines. From available information the B-35 was seen as the only currently projected VHB which could be expected to quickly approach the future requirements for airplanes to operate at 500 miles per hour and 40,000 foot altitudes. If compressibility effects were determined as not serious it was believed that the application of jet engines to the B-35 type would result in a far-reaching advance.[34]

Meanwhile Consolidated's projected XB-36 was also undergoing extensive experimentation and development. Designed along conventional lines, it was an all metal, high wing, single tail, ultra long range model powered by six R 4360-5 engines in a pusher arrangement, each engine developing 3000 horsepower for take off at 2700 r.p.m. Maximum speed of this giant airplane was estimated to be 367 miles per hour at 30,000 feet with a range of 10,000 miles carrying a 10,000 pound bomb load.

The XB-36 was designed to be considerably larger than the B-19, thus

dwarfing the B-29 and B-32. With a wing spread of 232 feet, a length of 163 feet, and an over-all height of 43 feet and 11 inches, the maximum gross weight was to be 269,039 pounds.

On a mission of 4790 miles, the mammoth XB-36 could carry a maximum bomb load of 72,000 pounds which was unprecedented in the history of military aircraft. Other features of the XB-36 included a retractable tricycle landing gear (dual wheels); pressure cabin; dual turbo engine superchargers; forward upper and lower turrets, locally operated and pressurized and mounting 37 mm cannon; two aft upper and lower turrets, remotely controlled and containing .50 caliber guns and 37 mm cannon; a remotely controlled tail turret with .50 caliber guns and 37 mm cannon; complete radio and radar equipment, and instrument landing devices.

Negotiations for the XB-36 began in August 1941 with the Consolidated Aircraft Corporation when preliminary design studies of a very heavy, ultra long-range bomber were requested by the Materiel Division. Upon approval of these data, procurement of two experimental models, based on the completion of wind tunnel tests, mock-up and detailed engineering information was authorized. The delivery dates for the initial two models were set for May and November 1944. However, due to an accumulation of unforeseen retarding conditions and factors, those dates could not be met. Principal causes for the delay included a revision of armament which postponed mock-up construction and inspection; redesign of wing and change from a twin vertical tail to a single vertical tail; problems arising in weight and balances control; delay in receiving engine for full-scale nacelle test; inability to conduct wind tests due to higher priorities which were necessarily given to other projects on production

prototypes. In addition a manpower shortage, especially of technical personnel, was constantly plaguing the project.[35]

Requirements for future bombardment aircraft were reviewed in a conference held at the Operations, Commitments and Requirements Office in Washington in March 1944. Representatives from Boeing discussed the suitability of current bombardment military characteristics and outlined a project for a jet propelled, high altitude, high speed bomber. As a result of this meeting, OC&R agreed to prepare and submit up-to-date requirements for all types of bombers from light to the very heavy model. Air Force representatives generally believed that a need would continue to exist for an improved version of a heavy bomber in the B-17 and B-24 class.[36]

The following month, the principal military characteristics for a long-range heavy bomber were established to guide the Assistant Chief of Air Staff, for Materiel, Maintenance, and Distribution, in planning future experimental projects. Requirements included a high speed of 525 miles per hour at an operating altitude of 40,000 feet; a service ceiling of 45,000 feet with design useful load; a range of 7000 miles with design useful load at operating altitude at an average speed of 425 miles per hour. A normal internal bomb load of 20,000 pounds was desired with an alternate internal gross load of approximately 40,000 pounds, interchangeability between bomb and fuel loads being essential. Leak-proof range extension fuel tanks were also to be provided in addition to leak-proof cells, particular emphasis being placed on reduction of fire hazards. Defensive armament consisting of .50 or.60 caliber machine guns or an improved version of the 20 mm cannon were to be located in fore and aft turrets with such other power mounts or turrets as deemed necessary

to provide effective protection during performance of missions. Computing sights were to be developed for these installations.

The normal flight crew would consist of pilot, co-pilot, flight engineer, two radar-bombardier-navigators, one radio operator, and the minimum number of fire control operators deemed necessary. The interior was to be so arranged that efficient performance of duties over maximum radius of action could be achieved. The crew as well as vital parts of the fire control system and engines were to be protected by flak curtains or deflector plates, and crew members were to be permitted interchange of stations during the mission. Latest type of radar and radio equipment, instruments and navigational aids, emergency oxygen apparatus in case of pressurized cabins, adequate window defrosting and air conditioning were to be provided to insure maximum crew efficiency at all altitudes, in all flying weather conditions, either day or night.

It was pointed out that those features of design that would permit maximum speed, altitude, stability of bombing platform, crew vision, flexibility of bomb load and fuel load, and the most effective defensive fire power were to receive primary consideration. Simplicity of maintenance, fueling, repair, replacement of main structural components, re-bombing and arming also were deemed highly essential.[37]

In reviewing the progress made in planning, developing, producing, employing, and modifying the heavy bomber since the outbreak of war in 1939, it is impressive to consider the multitudinous problems and difficulties faced and surmounted by the Army Air Forces and the aircraft industry in their concerted effort to provide a weapon of superior quality and performance. The VHB theory became a reality in late 1944

and throughout 1945 as B-29's pounded Japan into submission, and the following exercise in crystal ball gazing on the part of VHB proponents early in World War II took on added significance with each passing year:[38]

> By taking advantage of prevailing easterly winds, the planes /B-29's/ could take off from India or China, bomb Japan, fly to the United States, where refueling and minor repairs could be performed, and then fly to England via the Southern route, possibly bombing enemy installations in the Mediterranean on the way. From England, the planes would take off for the Orient, again bombing Germany on the way.

Chapter VI

INFLUENCE OF COMBAT ON HEAVY BOMBER DEVELOPMENT

Prior to America's official entry into World War II, the B-17C was given a trial operation to determine its effectiveness in high altitude daylight precision bombing. On 8 July 1941, three British-operated Fortresses were dispatched from an English base on a mission against the German naval base at Wilhelmshaven. On the way, however, when operational altitude had been reached, one of the Fortresses was forced to abandon the primary target because of excessive oil thrown from all engines which froze on the tail surfaces and fouled the controls, causing severe vibrations. This bomber had to descend to 16,000 feet to free the controls and stop the loss of oil, and it eventually bombed German airdrome on an island off the coast.

The other two B-17's, despite a similar loss of oil, reached the target area independently and released their bombs. One crew admitted missing the target and the other was doubtful if they scored a hit. No flak or fighter interception was encountered en route or during the bombing run. On the return trip, they were challenged by two German ME-109's, one trailing astern of one bomber while the other passed ahead in a climbing turn and made a quartering attack from front. The pilot of the attacked B-17 turned into the fighter which passed without firing a shot, zoomed to the rear, and then fell off in a spin. The second ME-109 followed a similar pattern with firing and dove after his spinning wingmate.

Although the German fighters had been in a good position to receive an effective burst, the front gunner of the B-17 couldn't fire because of window frosting and the side gunners also were unable to fire because a defective interphone system had prevented the fire control officer from warning of the fighters' position. During the return trip to the home base, the supercharger of one of the Fortresses failed but the bomber was able to maintain its altitude.[1]

Although this first mission was an operational failure, it represented a comb t test that pointed to the immediate necessity for correction of mechanical and electrical defects encountered in high altitude flying heavy bombers. It indicated the need for intensive training of air crews, particularly the bombardiers, in simulated combat operations with the same type of equipment.

Reports made by military attaches and other special military aviation observers in the belligerent countries, were received and used by the Materiel Division in collaboration with British analysts in making investigations of these problems. Outstanding among these were the need for increasing the critical altitude to approximately 35,000 feet, the simplification of controls, fully automatic carburetors, an improved oxygen system, efficient defrosting and de-icing devices, linkage between turbo control and throttle, leakproof fuel tanks, and automatic engine cowl shutters.[2] It was obvious that modifications in engines, structure, armament, and armor would have to be made on current production bombers and various changes incorporated in experimental models based on the trend of combat experience abroad. In the former case, studies and experiments had to be exhaustively conducted to determine improvements that could be safely made without jeopardizing

the flow of bombers from American assembly lines to Great Britain.

The European Theater of Operations (ETO): American heavy bombers had been designed and developed primarily for long range high level daylight precision bombing of specific targets. Consequently, critical factors were speeds high enough so that enemy fighters would not be able to fly rings around a formation, and the ability to carry heavy loads to extreme altitudes in order to escape the flak which was lethally effective during 1941 up to approximately 25,000 feet. Increased engine horsepower, gear-driven or turbo-supercharged, and heavy armament were the early answers to some of these problems.

The RAF, unconvinced of the value of daylight precision bombing with four-engine aircraft, was extolling the merits of safer night area bombing and pointing to their own accomplishments in that field. But American airmen held to their long-accepted bombing doctrines and maintained their faith in the practicability of daylight heavy bomber employment.[3] The RAF was further convinced that the B-17 would make a satisfactory night bomber but pointed out that its firepower was wholly inadequate for protection during daylight missions, and that its bomb capacity was too light to warrant the radius of action of which it was capable. The B-24, however, they considered a superior night bomber because of its greater bomb load and larger fuselage which made possible the installation of increased defensive armament.[4] The RAF also believed the B-24 peculiarly adaptable to coastal Patrol[5] for locating and destroying enemy submarines and the German Focke-Wulf patrol (FW-200) bombers. Although the Liberator had less defensive fire and high altitude speed than the B-17's it was still superior to the German bomber.

The B-17, with which the VIII Bomber Command started its official operations against occupied Europe, was the first of the improved combat model bombers and was equipped with heavier armament (tail guns and power turrets), protective armor, and had a greater speed and bomb load. A newly designed dorsal fin and larger tail gave it greater stability for improved accuracy in high altitude bombing. It also incorporated the new American invention--Automatic Flight Control--which permitted the bombardier through his manipulation of the bomb sight to control the flight of the airplane during the bombing run. With these modified bombers, precision bomb sights, latest tactical and strategic theories, and a nucleus of trained combat crews, the VIII Bomber Command set about a job in the summer of 1942 which had never been successfully accomplished by either the British or the Germans--the conduct of large scale daylight bombing missions.

In view of the fair success of the R.A.F in small daylight raids on Europe in late 1941, which had encountered strong enemy flak and fighter opposition resulting in the loss of several B-17's, it was debatable whether mass daylight bombing was feasible. Eighth Air Force leaders intended to demonstrate that it could be done. Thus, during 1942 and 1943, American heavy bombers, with increasing tempo, fought their way to vital targets, hit them, and fought their way back to distant bases, constantly harassed by a confident and determined foe. Against these bombers, the German Luftwaffe and ground forces pitted their three-fold mechanism of defense (which aerial bombardment itself had helped to create): radar detection, intense and accurate antiaircraft fire, and highly maneuverable, heavily armed fighters. Individual American bombers,

straggling from large formations, were pounced upon by waiting enemy fighters and destroyed. Some bombing runs were disrupted by skilled and fanatical Nazi air combat tactics, but the Fortresses and Liberators continued to strike through to their objectives with increasing numbers and accuracy and with relatively minor losses. For the time, at least, a strategic offensive weapon had proved superior to the most effective forms of tactical defense.

In this connection, General Arnold pointed out late in 1942 that the B-17, although in some instances attacked by as many as 75 ME-109's or FW-190's, was rugged enough to limp back to its base with hydraulic system destroyed, control wires severed, gunners wounded or killed, the co-pilot knocked out, and the plane practically out of control. Despite losses American heavy bomber attrition had remained comparatively light considering the large numbers of enemy fighters shot down. Up to 7 December 1942, only 21 B-17's were lost and another 25 missing in action; yet the bombers had destroyed a total of 301 Nazi fighters--a ratio of 6 to 1.[6]

Perhaps the most important development, arising out of this early combat experience was increased fire power, since enemy fighters were reckless and aggressive and pressed home their attacks with telling effect despite the murderous defensive power of the .50 calibers firing armor piercing and incendiary bullets at the rate of several hundred shots per minute.

Early in 1943 the Eighth Air Force asserted that the heavy bombers "were still able and shall continue to knock down better than 6-1 enemy fighters for our bombers losses . . . . We can, however, reduce our

losses and greatly increase enemy losses as soon as we have the front or chin turret. The Germans are now making frontal attacks almost exclusively and all our recent losses have resulted from this form of attack."[7] Nose assaults nearly stopped American daylight bombing in early 1943, and it was only the installation of nose guns--and later chin turrets--that relieved this critical situation in time.

Increasing American bomber defensive armament was of special importance, because the long-range escorting fighter had not yet put in an appearance. Just what constituted "effective" firepower was the subject of considerable debate, study, and experimentation, and, it was conceded that the mere presence of numbers of guns or cannon, irrespective of caliber, was not indicative of true firepower. Both the B-17 and the B-24 had to be treated separately and every conceivable consideration given to the number of weapons, their caliber and, above all, their location in the aircraft to assure maximum protection. A great deal of stress was placed on power-driven turrets for all sizes of machine guns and cannon. Such installations included locally operated, remotely controlled, and power boosted hand-held mounts. The latter were vast improvements over the original single hand-held flexible guns of early model B-17's, inasmuch as larger caliber, multiple weapons could be more accurately controlled and sighted free from the slipstream effect encountered at high speeds. The improved armament installations on the B-17E and F did much to command the respect of the Luftwaffe fighter pilots in 1942. In addition newly developed automatic computing sights forced enemy fighters to remain at a range from which their firepower was comparatively ineffective, and contributed greatly to the

success of heavy bomber missions over Germany.

Advancements in bombardment aircraft armament since the outbreak of World War II had necessitated the development and construction of new testing facilities, which included indoor and outdoor firing ranges, cold rooms for test firing at extremely frigid temperatures, high altitude pressure chambers, sight and computer testing devices, and advanced electronic testing equipment. Since American heavy bombers had to fight in both arctic and desert temperatures, it became mandatory to design armament for perfect operation in all climatic and atmospheric conditions. Thus, testing temperatures have ranged from minus 65 degrees to plus 160 degrees Fahrenheit, and high altitude armament operation was being continually studied in pressurized chambers. New greases and oils to allow smooth functioning of guns at extreme operating temperatures were also developed. Effects of cold and heat on the thick transparencies around windshields and turret installations required extensive study and new types were designed to offset damaging temperatures. And, exhaustive tests of fire expectancy of guns and cannon produced innovations in construction and installation methods that assured maximum efficiency at high altitude and under concentrated enemy fighter attack.

The Commandant of the Air Forces School of Applied Tactics advised the Commanding General of the Army Air Forces, that improvements in aerial gunnery were also needed. Increased muzzle velocity was advised to increase range, flatten trajectory, and improve the percentage of hits. Installation of .60 caliber guns rather than 20 mm. and 37 mm. cannon turrets was suggested since the charge of the former was about the same as the 20 mm. cannon but it had a higher muzzle velocity, flatter trajectory,

and longer range. The 20 mm. had too much drop and the 37 mm. too much weight for satisfactory combat results. In concluding, the Commandant warned: "We know that the engineers will say 'it can't be done' with regard to much of the above. They told you [General Arnold] that when you insisted on more guns and leak-proof tanks for our fighters--but they did it, and where would we be today if they hadn't been made to do it?"[8]

As a stop gap to counter the growing intensity of German fighter opposition, modified B-17's were heavily armed and armored, redesignated YB-40's, and introduced into the European theater in mid-1943 as "fighter-destroyers" to accompany and protect heavy bomber formations in deep penetration missions over Germany.[9] Masquerading as B-17's they flew in the most vulnerable position of the combat boxes. Although they took the German fighters by surprise and achieved a tactical victory, the YB-40's were later eliminated. The very features which had rendered the escorting bomber particularly formidable--two extra .50 caliber guns, extra armor, extra ammunition, a chin turret for protection against frontal attacks--proved detrimental in actual combat since the bombers it was protecting were faster after being relieved of their bomb loads and less susceptible to straggling when an engine was damaged.[11] Many of the new features incorporated in the YB-40, however, were later adapted to the B-17, improving its defensive armament and armor until long distance fighters were available for cover protection.[12]

The same exhaustive research and experimentation applied to developing superior armament was also applied to the improvement of oxygen systems and interphone communications; window defrosting; de-icing equipment; electrically

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herted flying suits, helmets, goggles and gloves; armored vests for crew members; flak curtains and leakproof fuel tanks; turbo superchargers; automatic flight control; dampening flame exhausts; increased engine horsepower and cylinder cooling; and many other items that go into the final makeup of a fast, strongly armed and armored, high altitude heavy bomber and its combat crew.

After standardization and procurement of new equipment, work was continued by manufacturers in collaboration with the Materiel Command to further improve the article. Since airplane production was on an assembly line basis, however, it was impractical to expect frequent revamping of assembly lines and still continue to have an uninterrupted flow of bombers to the combat theaters. The task of modifying the airplanes logically could not rest exclusively withe the manufacturer. To alleviate the constantly growing demands for changes in combat bombers, Modification Centers were established in 1942 through the cooperation of airline organizations and later the aircraft manufacturers. Since these planes were destined to go to all parts of the globe, with the heaviest need in the ETO, the Modification Centers made last-minute changes according to special combat or geographical requirements.[13]

Shortly after the 14 October 1943 mission against the ball-bearing plant at Schweinfurt, when 66 American bombers were lost out of a force of 295, the Eighth Air Force admitted that it could no longer continue long range daylight heavy bomber operations against Germany because of the mounting heavy losses imposed by enemy fighter action. In the great air battle which raged during the approach and departure from the Schweinfurt target, the Luftwaffe had employed over 400 fighters. Over 700 attacks had been pressed from altitudes as high as 34,000 feet.

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All known air tactics--and many derivations--were used by the enemy to break up the formations, including lobbing rockets at a range of approximately 1000 yards, air-to-air bombing, and radio jamming to prevent communications between the bombers and short range escorting Allied fighters. The fighters later had to withdraw because of limited fuel after covering the mission for 240 miles to the Sittart area on the German border. No returning support could be given the bombers because of dense fogs at fighter bases. Unfortunate stragglers from the bomber formations were immediately attacked by swarms of German single-engine fighters and blasted out of the sky.[14]

Air strategists immediately adopted a policy which demanded continuous and extensive fighter cover in target areas where the Luftwaffe might be able to concentrate an effective defensive force. This was a tacit admission that, despite exceptional improvements in speed, altitude, armament, and armor, even the largest heavy bomber formations would prove vulnerable to latest enemy air tactics and weapons. It seemed that the best efforts of the VIII Bomber Command had been decisively excelled by the Germans. Timely arrival of the latest long range fighter escorts saved a critical situation and permitted uninterrupted continuation of the Combined Bomber Offensive (CBO).

In searching analysis of the operational problems of the American long range heavy bomber daylight offensive against Germany the Eighth Air Force made a number of modification recommendations based on combat experience since the first bombardment mission in August 1942. Armor protection for engines was labeled of highest importance, since most bombers were lost as a result of battle damage to power plants and consequent

stragglng from the formation. Next in importance was the reduction of fire and explosion hazards. It was considered urgent to devise some method of protecting the engines, fuel tanks and tubing, perhaps by extinguishers attached to engine nacelles and fireproofing of tanks and feed lines. Increased armament, including improved guns, automatic computing devices and turret operation, were strongly urged, the type and location of armament based primarily on the direction and relative effectiveness of fighter attacks. For example, late in 1943 the preponderance of fighter attacks and hits on heavy bomber formations was from the tail (5,6, and 7 o'clock). Enemy fighters, in particular, pounced upon stragglers from that vantage point, and such attacks were likely to increase in proportion to the number of bombers equipped with nose or chin turrets. Almost equally frequent were frontal attacks (11,12 and 1 o'clock) in which the enemy had the greatest relative advantage since hits from that direction were more likely to be lethal to the bomber and crew than from any other position. Compared to the number of passes made, hits were more often scored in that quarter. On the other hand, side attacks (2-/ and 8-10 o'clock) were fairly infrequent and the hits relatively few.

To counteract these intense and effective enemy air tactics, the Eighth Air Force recommended that the fullest long range protection be afforded to the rear quadrant, providing a tail turret with a wide area of fire. Nose turrets should be installed to increase protection from the deadly frontal attack, and the possibility of adding horizontal fire in the nose and tail quadrants of the upper ball turrets to eliminate existing dead zones should be re-explored.

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Another hazard to efficient operations was self-inflicted damage, especially to the B-17's, caused by waist gunners firing to the rear and hitting horizontal stabilizers and elevators, and damaging the wing tips when firing frontward. The radio-gunner's bullets occasionally hit the vertical stabilizer and those of the ball turret guns also struck the bomb bay doors when opened. Possible solutions to this hazard were to incorporate interruptors on waist guns or provide a modified waist design. If waist guns were entirely eliminated, fire interruption of some kind should be installed to avoid self-inflicted damage on any arrangement covering similar defense zones.[15]

In the ensuing months of 1944, the Materiel Command directed intensive research and experimentation toward solving these critical problems. Many had already been under study for some time. Exhaustive testing of the improved features of the heavy bombers was then conducted by the Proving Ground Command at Eglin Field. In some cases, particularly in new armament developments, experimentally equipped bombers were flown to the European theater for trial in actual combat before extensive modifications were made.*

Ultimately, the B-17G emerged with many of the armament features which the VIII Bomber Command urged: the Bendix chin turret mounting two .50 caliber guns for operation by the bombardier; one hand held .50 caliber staggered on either side of the nose and firing forward and to the beam for use against converging frontal attacks in case the chin turret was shot out of action; an improved Sperry upper turret with two .50 calibers having the K-3 computing gunsight; one hand-held .50 caliber at each enclosed waist window-staggered-on K-6 mounts; a Sperry

* E.g. see case of AB-40, this chapter above.

lower ball turret with two .50 calibers and K-4 sight; two .50 caliber tail guns, having a 110 degree azimuth cone of fire and using optical N-8 and N-6 sights. Some of the B-17G's were also equipped with improved superchargers (B-22) which gave better high altitude performance, special radar devices (AN/APS-15) for bombing through the overcast, and high altitude radar altimeters (SCR-718).[16] Snap-open bomb bay doors also were sent to the Eighth Air Force for installation and combat testing on several of their B-17's.[17]

In another analysis of combat operations, it was found that antiaircraft fire was responsible for nearly all of the battle damage to the American heavy bombers in late 1943 and early 1944 and had caused a number of casualties despite airplane armor and armored crew vests. The Eighth Air Force Operational Research Section had estimated that their day bombers had experienced ten times the damage inflicted upon the British night bombers which could take evasion action all the time, even over the target. The ability of the B-17 and B-24 to absorb a lot of flak and still return to their bases was considered the most valuable military characteristic of these airplanes.

It was pointed out, also, that although fewer German fighter attacks were now occurring, in comparison with the number of bombers sent out, these fighters were becoming more lethal particularly in frontal attacks which severely damaged engines. From a study of the location of all combat hits, the Eighth Air Force recommended armoring engines in the the following order of importance: (1) the front and the cowling leading edge, which should be of steel; (2) the underside of the engines which should be of steel-- or duralumin if weight would not permit the use of the former. It was also believed that either of these metals should

be used in extending the protection beyond the underside armor, over the outer skin of the nacelle, to well behind the fire-wall and cooling gills. It was proposed to collect all evidence possible to determine where armor could be saved elsewhere in the bombers, in order to decrease the vulnerability of the engines to rocket and cannon shells and the gradually increasing flak.

In view of the imminent adoption of fuel-injection on engines, the Eighth Air Force, also advanced the possibility of using safety fuels as a means of reducing the inflammability of the heavy bombers in combat. Changes necessary to convert fuel injection engines to spark-ignition heavy fuel operation would help eliminate the explosive risks encountered with gasolines at high altitudes and reduce the need for fuel tank purging and gasoline protection.

The relative merits of the British high pressure and American low pressure oxygen systems were also discussed and great importance was attached to reporting oxygen and hydraulic equipment and containers to decrease the fire hazard in case of hits on either. Non-inflammable hydraulic fluid was urgently required.[18]

Some of these critical needs were temporarily met shortly afterward when 25 B-17G's equipped with engine armor were dispatched to the VIII Bomber Command for trial and approval before action was initiated to supply production models with this equipment.

To aid in avoiding rocket attack, water injection for heavy bombers engines was under concurrent study by the Materiel Command and was to be ready about December 1944. In the meantime, another method was developed

to increase speed through changing the carburetor enrichment jet and needle; this increased the horsepower rating of the 1820 engines from 1200 to 1400 at 2500 r.p.m., thus providing an added 20 miles per hour at 20,000 feet. Water injection, when available, would produce an additional 17 miles per hour.[19]

In the Schweinfurt battle of 14 October 1943, when the VIII Bomber Command lost more aircraft in a single day than it had lost in the first six months of operation over Europe, it was starkly apparent that the perpetual struggle between offensive and defensive weapons was becoming more intensified. The Germans, well aware of their growing inability to protect vital targets throughout the Reich, were expediting the development of counter weapons and making radical changes in fighter tactics to stop or retard the deadly effectiveness of precision bombing and the massed defensive fire power of American "heavies." The Luftwaffe was employing every available weapon of defensive air warfare and developing newer ones in a desperate effort to break up huge bomber formations and destroy the strugglers.

During the winter of 1943-44, heavy bomber operations conclusively showed that radar bombing through overcast had greatly helped the VIII Bomber Command to maintain maximum pressure on Germany and continue to cause heavy attrition in the Luftwaffe, exclusive of physical damage to targets. German fighter crews had to be constantly alerted and were compelled to operate under the most unfavorable of weather conditions.

Nevertheless, in the first quarter of 1944, the total number of B-17's lost or damaged on combat missions reached the dismal total of

4233--or 13 per cent. Of this number, 566 were shot down in combat as a consequency of crippling enemy fighter attacks or flak damage. The B-24, because of its greater vulnerability, was employed on easier and fewer missions, suffering a total loss or damage of 1006 of which 210 were downed from the causes previously mentioned.[20]

Although not all of the lessons of air warfare in the employment of heavy bombers have been learned in the European theater, most of the major modifications in design, armament, and armor were a result of the extensive combat experience in that theater and proved to be of great advantage to other American air forces.

Mediterranean Theater of Operations (MTO): American heavy bomber operations in the Mediterranean theater faced, mainly, special materiel problems arising out of weather conditions and temperature and locale factors. The tremendous range of temperature in Africa and the Middle East, ranging from 35°F in the winter to 135°F in the summer, together with the abrasive dust and sand that penetrated and ruined the engines, armament, bomb sights, turrets, and other intricate equipment, posed a serious problem for Materiel Command engineers. In order to solve it, dust excluders and special filters were designed and developed, as well as coverings for engine nacelles, propellers, turrets, guns, cockpit windshields.[23]

German fighter tactics against the heavy bombers in the Mediterranean theater were in general similar to those employed in the European theater. They frequently attacked bomber formations from all quadrants but the majority of attacks were frontal, particularly against the B-17's. Rocket-firing fighters, air to air bombing, decoy tactics, massed formations,

and well coordinated attacks were all used by the Luftwaffe against formations over Italy in 1943.[22] Thus, B-17E's and B-24D's dispatched to the MTO in late 1942 were standardized as far as practicable with those going to other theaters. Deviations from the norm for the Fortresses included fusing control for nose and tail fuses of British bombs, B-9 bomb shackles modified for British general purpose bombs; radio compass with CW and 200 KC component (BC433-C); provisions for installation of flame dampers; dust excluders and vacuum instrument filters; removable intake air filters; desert camouflage; and adapters for British battery carts. Liberator modifications were similar.

Pacific Theater of Operations (PTO): Heavy bombers were employed in the Pacific Area under conditions ranging from the intense cold and barrenness of the Aleutians to the humid, stifling heat of the thick jungles of the Southwest Pacific against an enemy whose air tactics varied from excellent to very poor and whose antiaircraft fire ranged from intense and accurate to weak and ineffective.

In the Northwest Pacific, heavy bombers of the Eleventh Air Force operating in the Aleutians fought the weather more than they did enemy aircraft. In the most variable climate in the world dense fogs and high winds blew in from different directions simultaneously, heavy rains made lakes or quagmires out of American air bases. Modification of all B-17's and B-24's was imperative to keep them in operation. Accurate determination of materials and methods was essential to insure combat performance in temperatures as low as minus 65°F. Bombers standing in such temperatures for a period of six to eight hours had to be capable of being started with a minimum of delay.[23] Typical problems that had

to be solved were shrinkage of parts of the aircraft at different rates depending upon whether the parts were aluminum, steel, or rubber; the hardening of engine oil to stone; and the thickening of glycol coolant to jelly. Hydraulic hose became brittle and charred; and tires cracked like china. To protect the airplane against the effect of this great cold "31 separate winterization requirements were developed, each the result of long and difficult months of research."[24]

The Materiel Command and the Cold Weather Testing Detachment at Ladd Field, Alaska, were called upon to solve these problems in winterization. Some of their modifications were full closing automatic shutters on the oil radiator; an oil dilution system; a glycol system of cabin heat with engine boilers, with piping back to tail gunner, the ball gunner, and the glass dome on the top gun turret; outlets for connecting electrically heated suits; snow- and ice-tread tires of the spring wire type; special non-freezing grease for lubricating control systems; lagging for engine parts; an oil immersion heater; a special hydraulic system; full closing engine cowl flaps; deicer boots on wings and horizontal and vertical stabilizers; supercharger regulators operated by oil from the main engine oil system; windshield wipers and deicing system for the pilot cabin windows and the bombardier's observation window; provisions for auxiliary engine priming with propane; lagging of oil tanks and lines except those which were self-sealing, and many others.[25]

Combat experience in this theater necessitated no major modifications in armament and armor. The winterized heavy bombers were capable of countering any enemy fighter and antiaircraft action provided by the Japanese.

Combat missions performed by heavy bombers in the Central Pacific were primarily long range in character and from few and widely scattered bases. Although predominantly a Navy theater, the Army Air Forces was the strategic arm of the fight against the Japanese, working in close support with the carrier-based tactical naval air arm. With the latest modified heavy bombers on hand, having greater range, fire power, and bomb load, the Seventh Air Force was prepared to carry on offensive against Japanese bases and water-borne targets hundreds and even thousands of miles away. In those long range operations no fighter cover could be provided, and strong armament and armor and skilled gunners were to make up for this lack.

Area bombing in this theater was practically unknown. Objectives had to be pinpointed and each bomber made an individual run. In view of this fact, Japanese fighters and flak were able to concentrate on the ship before and after crossing the target, while an intense antiaircraft box barrage was thrown up over the target itself.[26]

The B-24D's first received in the Pacific Theater were equipped with five separate .50 caliber machine guns in the nose, thus making it difficult for the gunner, and impossible for the bombardier, to fire during a bombing run. Consequently an improvisation was made at the Hawaiian depot of the Seventh Air Force: the rear gunn turret was transferred *in toto* to the nose. This proved so successful in later combat operations that it was adopted, with improvements, for production models of both the B-24 and B-17.[27]

Subsequently reports from the combat crews resulted in numerous recommendations to the Materiel Command. Because of the prevailing Japanese fighter tactics increased armor plate in the nose, the waist, and the side

of the tail compartments of the B-17E was decided, as well as a new type belly turret to replace the malfunctioning old type. Other armament suggestions included a redesigned "eyeball" turret since the present one was too confusing, causing cold and cramps at high altitudes; two side mounted .50 calibers instead of one; at least one .50 caliber in the radio compartment and as many as six .30 calibers in the nose. Pilots maintained that the automatic flight control equipment was unsuited for formation bombing in the usual adverse weather conditions and that the B-17E had inadequate range. New linings in the self-sealing fuel tanks were reported necessary after only four or five weeks of using fuel obtained at Pacific bases and pilots asked for additional self-sealing bomb bay tanks.

Frequent contradictions in recommendations from combat crewmen constantly plagued the Materiel Command's modification program. For example, while B-17 airmen were clamoring for greater range as well as improved self-sealing tanks, the B-24 pilots were complaining that the installation of self-sealing tanks in their planes was reducing gasoline capacity. And again despite the fact that the B-24D's were said to have a limited 20,000 foot ceiling with a full load, heavier armor protection was required. For armament the Liberator crews recommended more .50 calibers on a 360 degree ring mount in place of the over-heavy and less-effective bottom turret.

Although many of these modification suggestions were not peculiar to the Pacific theater the continued demands for greater fuel capacity and fire power (which were later echoed by B-29 airmen) were motivated by the theater strategy of long range--and very long range--tactical missions, which had to be performed (until 1945) without the aid of long range fighter escorts.

Chapter VII

SUMMARY AND CONCLUSIONS

In World War I the bomber was a new offensive weapon, limited in numbers, crude in performance and employed in a desultory manner. The majority of high ranking Army and Navy Officers, preoccupied with their particular spheres of combat operations, believed that the bomber was chiefly valuable for conducting "nuisance" raids and not for delivering decisive blows upon enemy military installations and industrial areas. As an independent striking weapon, overshadowing land and naval warfare, the bomber had failed to make a lasting impression of its effectiveness upon the orthodox military mind.

After the war, the future of the heavy bomber was debatable. Meager peacetime appropriations and the return of the nation to "normalcy" did not augur well for building up a strong air power with offense as its keynote. For over a century, the American military policy had been one of defense and non-aggression. Adequate land and sea forces were accepted as necessary to protect the coastline and insular possessions, but the American people did not directly concern themselves with determining what actually constituted adequate defenses. This responsibility was left to the military establishment, and when friction arose over the primary functions of the Army and Navy in national air defense, it was generally viewed by the nation as a "family" quarrel. While both the Army and Navy agreed that the airplane--particularly the land based, long range heavy

bomber was essential to national security, they disagreed over which branch of the service should control its development and employment. Air power was a new element to the Army and Navy, and to those experts whose only considerations for defensive planning had hitherto been based upon the strategy and tactics of land and sea warfare, its future role was still questionable.

Between 1918 and 1935, although some notable advances were made in general design and performance of the Army heavy bomber, there continued to exist an unwillingness on the part of Army leaders to concede to this airplane a prominent place in the defense plans of the nation. The concept of the superiority of the bomber over the best weapons of land and sea, vehemently insisted upon many airmen in both branches of the service, aroused considerable antagonism in the War and Navy Departments. This was particularly true when enthusiastic Army bomber proponents pictured the functions of the dominant defense arms as incidental to a larger and more original employment of aerial bombardment than had yet been established on a practical and workable basis. In 1935, with the advent of the long range four-engine B-17, the picture of national defense materially altered in theory and practice, but the War Department continued its policy of restraining four-engine bomber development and procurement. By June 1938, however, a favorable change occurred in the attitude of the War Department toward the purchase of heavy bombardment aircraft, although only in a limited degree. As a result, the GHQ Air Force had only fourteen four-engine bombers in service as late as 1 September 1939 and it was not until the eve of World War II that permission was granted to procure an additional

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number of the four-engine B-17's--exclusive of the original order of thirteen in 1935.

In the physical development of bomber types, the Materiel Division was handicapped for many years, especially in the late thirties, by limited appropriations and restrictive policies placed on bombardment research and development by the War Department. Inability to produce a variety of experimental heavy bomber types unquestionably contributed to the critical aircraft situation presented by General Arnold early in 1938, when he compared American four-engine bombers with those of foreign powers. With the exception of experimental development of the XBLR2 (XB-19), started in 1935, and the XB-24 which was designed and produced in 1939, the status of heavy bomber experimental construction was practically at a standstill when World War II broke out.

Perhaps the clearest appraisal of the pacifist attitude of the American people, which also materially impeded the development of the heavy bomber between 1918 and Pearl Harbor, was the statement made later by General Arnold at the West Point Military Academy. "The United States had gone through a period in which the common cries were: hemisphere defense, who are you going to fight, why do you need all this equipment, for what purposes do you need all those planes? let Europe solve its own problems--we don't need an army--we can't be attacked, the Atlantic and Pacific are impassable barriers." Then, in reference to heavy bomber development, he stated that the "Air Corps championing of the long-range, multi-engine type has been amply vindicated," and that the Army Air Forces had been built around the B-17 "Flying Fortress".[1]

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After the outbreak of the European War, the restrictive attitude of the War Department toward heavy bomber development underwent a gradual change. General Marshall, the new Chief of Staff was convinced of the necessity for building a strong air power around the heavy bomber; Henry L. Stimson, the new Secretary of War favored military aviation expansion and development; and Robert A. Lovett, the new Assistant Secretary of War for Air, having been a World War I flyer, saw the immediate need for bolstering the air defenses of the nation. In the early months of 1942, while Air Corps and aircraft industry leaders were laying the foundation for mass production of heavy bombers, the first models to roll off the assembly line were dispatched to the United Kingdom to augment her limited bomber production which was still recovering from the staggering blows of the Battle of Britain.

As a result of the RAF employment of American heavy bombers in offensive strikes against Germany, the potentialities of these airplanes as a powerful striking weapon against the industrial heart of the enemy, were duly recognized in high military and executive circles. Consequently, production was stepped up to a goal of 1000 per month, and by October 1943, this goal was achieved.[2]

In view of the fact that the majority of the heavy bombers produced before Pearl Harbor were diverted to the RAF, on the eve of the Japanese attack, on Pearl Harbor the Air Corps had only 31 heavy bombers at strategic insular outposts and most of these were unequipped for combat operations. The few that were not destroyed on the ground performed miracles in delaying enemy operations and proved their inherent ruggedness against overwhelming fighter attacks.

In the hectic months that followed America's entry into the war, all opposition to heavy bomber development gradually vanished, and every effort was concentrated upon increasing the production of B-17's, B-24's and the new superbombers--the B-29 and B-32. Extensive research and experimentation programs were also underway to provide bombers possessing superior military characteristics and performance to the preceding models, and high priority projects were taking form in the development of ultra-long range very heavy bombers designated as the XB-36 and XB-35. By the end of 1944, these carefully laid plans bore fruit with the initial B-29 raids on Japan proper, culminating in the mushroom growth of the war-ending Nagasaki atom bomb.

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Appendix A

THE ARMY AND NAVY CONFLICT OVER THE LAND-BASED BOMBER*

Before the advent of the combat airplane, the respective functions of the United States Army and Navy in national defense were well-defined. It was the traditional mission of the Navy to intercept and destroy at sea any enemy fleet threatening the security of the nation. If the enemy proved superior, the American fleet was to withdraw to the protective zones of shore defenses and, in collaboration with the Army, repel invasion and seizure of coastal areas.[1] Normally, under such a system of coastal defense, no major difficulties could arise regarding the responsibilities of the Army and Navy, since it was established that Army coastal defense depended upon the maximum range of its land-based weapons.

After the introduction of the bomber in World War I, however, the century-old defense policies of the services underwent a substantial change. The Army air arm by 1917 recognized the potentialities of air power and was formulating plans for the establishment of air bases in the Philippines, Hawaii, and the Canal Zone, as well as the United States; the Navy, with full knowledge of the Army's function in coastal and inland defense, had also made extensive plans to expand its air arm ashore.[2]

In 1919 the Navy presented its projected plan for air stations near locations previously designated or developed by the Army so that

* See also "Controversy Between Army and Navy on Landbased Aircraft," AFHD file 145.91-565, Coast Defense.

it could operate land-based aircraft therefrom. Congress recognizing that duplication of effort might result, enacted legislation prohibiting the Navy from maintaining more than six heavier-than-air stations along the coasts of the continental United States.[3] Although this provision annually passed as part of the naval appropriations act, the Navy proceeded to carry out as far as possible its original plans to control shore-based bombardment for patrolling the sea lanes.[4]

Congress later supported the Army claim that it was being infringed upon by the Navy and inserted a provision in War Department legislation that attempted to define the aviation functions of each service. By the act of 5 June 1920, control of all land-based operation of bombardment aircraft was assigned to the Army and control of all fleet air operations was delegated to the Navy.[5] Armed with this congressional interpretation of air defense responsibilities, Air Service bomber proponents began to champion the development of superior long-range aircraft for coastal patrol and interception at sea of an "enemy" invasion fleet. The Navy immediately protested that such a tactical doctrine violated its long-accepted duty of protecting the coastal sea lanes and guarding the nation on the high seas, and advocated that all aerial bombardment be assigned to the Naval Air Service as part of its reconnaissance operations from shore stations.

The issue of the control of land-based bombardment was reviewed by the Chief of Air Corps in 1927. He called attention to the persistent Navy effort to wrest air defense functions from the Army and stated that neither service could harmoniously agree upon joint defense plans. He complained that annual aviation budgets were independently submitted

by each service and acted upon by separate congressional committees, and that this lack of coordination resulted in excessive naval appropriations for its arm, thus placing the Army at a disadvantage in pursuing its own aviation development.[6]

One phase of the Army-Navy controversy stemmed from the fact that the Army was organized at minimum strength in peacetime, since it was the Navy that was traditionally accepted as the "first line of defense" in time of war. Not until war was imminent would the Army mobilize to its required strength, protected meanwhile by the strong naval fleet and coastal fortifications.[7] With the advent of the long-range bomber, however, Army aviation leaders could not accept this outmoded policy, since their defense operations were no longer restricted to the coasts. So much pressure was brought to bear upon Congress by both services in their endeavor to acquire control of land-based bombardment that a select committee was appointed to investigate the "Duplication of Air Effort." The committee cited the construction of naval air stations at Hawaii and Panama, and the duplication of Army bombardment and pursuit aircraft as outstanding examples of the wasteful expenditure of public funds. It recommended that this situation be remedied immediately,[8] but there is no record of any decisive action taken to restrain naval air development.

The matter of defining Army and Navy air defense responsibilities was referred to the Aeronautical Board in May 1927, but again no agreement was reached. Thus, the divergent views of the service representatives were finally submitted in separate reports to the Joint Board. In the Navy report, an amendment of existing policy was

recommended to permit the employment of naval aircraft "for attacking enemy vessels over the sea by torpedoing and bombing."[9] General Patrick, the chief of Air Corps, who was the Senior Army Member of the Aeronautical Board, strongly opposed this recommendation as a definite Navy attempt to alter existing law and regulations so that it could acquire greater control over land-based bombardment aircraft. He cited as an illustration the expansion of naval heavier-than-air facilities at Sand Point, Wash., which had originally been established as a maintenance and supply base. Yet, in the Naval Estimate of Funds submitted for 1927, the construction of a large hangar, runway, and beach had been included, which clearly indicated an intention to assign land-based aircraft to this area. Patrick recalled that in a previous meeting of the Aeronautical Board in November 1926, the Chief of the Navy Bureau of Aeronautics had declared that the Navy should be charged with all land-based operation of bombardment and pursuit aircraft in order to provide unity of air command and to assure adequate coast defense.[10]

The Assistant Secretary of War for Air F. Trubee Davison supported General Patrick in this review of the long-standing Army-Navy conflict over air defense. Subsequently the Judge Advocate General John A. Hull, rendering an interpretation of the legality of the much-disputed law segregating coastal air defense responsibilities, advised that the clause in question constituted "general legislation of continuing application" and therefore could be enforced.[11] In view of this ruling the responsibility for compelling the Navy to discontinue its unauthorized duplication of Army air effort was placed squarely upon the War Department. Brig. Gen. J. E. Fechet, Assistant Chief of Air Corps, urged that

immediate action be taken and, if necessary, that the War Department sponsor further legislation to strengthen its case. He reiterated Patrick's warning that the Navy was increasing its land-based bomber and pursuit aircraft in preparation for assuming control of Army defense functions.[12]

Although Air Corps leaders continued to complain about the secondary role of their component in the Navy-dominated national defense picture no deliberate action was taken by the War Department. Thus, during the late twenties and early thirties, despite the exchange of numerous memoranda and studies, meetings of the Aeronautical and Joint Boards, occasional compromises, and strong words exchanged between high ranking Army and Navy officers, the issue remained unsettled. Meanwhile Air Corps investigators discovered what seemed to be a careful Navy plan to oust Air Corps combat units from coastal air bases.[13] The first evidence of this plan came to light in August 1930 when Secretary of War Patrick J. Hurley received a copy of a letter sent by the Navy Department to President Hoover, containing severe criticism of the Army air defense program. Shortly thereafter, the Secretary Hurley refuted the statements made by the Navy and outlined to the President the unsatisfactory status of coastal defense. He blamed the confusion which surrounded Army defense responsibility on the aggressive Navy attitude and deplored the latter's unchallenged land-based aviation development since the passage of the Act of 1920. Immediate steps must be taken to correct the situation, he stated, or the entire national defense system would be jeopardized.[14]

Accordingly, on 9 January 1931, the Chief of Staff, General Douglas MacArthur, and the Chief of Naval Operations, Admiral W. V. Pratt, reached

a mutual agreement based on the congressional statute of 1920.[15] By this agreement the air force of each service was to be "free to develop within well defined limits and each with a separate and distinct mission."[16] In his annual report a few months later General MacArthur defined the agreement in these terms:[17]

> Under it the naval air forces will be based on the fleet and move with it as an important element in performing the essential missions of the forces afloat. The Army air forces will be land based and employed as an element of the Army in carrying out its mission of defending the coasts, both in the homeland and in overseas possessions. Through this arrangement the fleet is assured absolute freedom of action with no responsibility for coast defense, while the dividing line thus established enables the air component of each service to proceed with its own planning, training, and procurement activities with little danger of duplicating those of its sister service.

Despite MacArthur's conviction that the question of coastal air defense was settled the Navy continued to develop its land-based aircraft, expansion of naval air stations continued, and the Navy employed bombers under the guise of "torpedo" and "patrol" airplanes.

Early in 1934 the Army members of the Aeronautical Board, in reviewing naval aviation estimates for the next fiscal year, charged that the inclusion of patrol and torpedo planes not only violated the Pratt-MacArthur agreement but the Naval Operating Policy as well. When the Navy Bureau of Aeronautics objected to this allegation the Board wrote separate letters to the War and Navy Secretaries requesting a decision.[18] Meantime, the Air Corps charged that naval air units had gradually infiltered into Army air stations at Rockwell Field, Bolling Field, Luke Field, and Fort Lewis, and were maneuvering to establish units at Langley Field, Mitchell Field, Albrook Field, and France Field.[19]

Later in that year, the long dispute between the Air Corps and the Navy Department received an extensive airing in the private hearings conducted by the Federal Aviation Commission. Secretary of War George H. Dern invoked the air defense policies established by the Joint Board, while Secretary of the Navy Claude A. Swanson criticized the Army's part in the system, repeating many of the issues previously discussed and placing special emphasis on limiting Air Corps aircraft development to those types required for land operations against an enemy engaged in ground warfare.[20]

Between 1934 and September 1939, the dispute over air defense remained unsettled, each service continuing to expand its aviation facilities to the full extent of annual appropriations. In joint committee and board meetings, although there was growing evidence of attempts to coordinate aviation problems (especially those regulations covering joint action in case of war), friction arose when the Navy insisted upon assuming responsibilities lawfully charged to the Army. The Air Corps studied the Naval Appropriation Bill for 1937 and, at its request, the General Staff was informed that the Navy had requested 73 twin-engine and six four-engine patrol bombers to be used for coastal reconnaissance and protection of the sea lanes.[21] Thus the Navy continued to ignore the Army's authorized control of land-based bombardment.

Early in 1939 the Plans Section pointed out that the Navy had eight air stations within the United States, one other under construction, and four additional ones recommended to Congress for early development. This program, the Chief of Plans declared, directly violated the Act of 1920, an act interpreted by the Navy, he said, as "just so many useless

words." Six major naval air bases (three on the east coast and three on the west coast) were preparing to handle from 22 to 27 heavy bombardment squadrons. He recommended, however, that no action be taken by the Air Corps to prove duplication of bombardment effort, since it would be difficult to disprove the Navy's statement that the patrol (bombardment) airplanes were needed for long-range reconnaissance with the Fleet.[22]

Because of the geographic and strategic isolation of the United States, the connection between sea power and air power was intimate. Initial air force operations, in case of an attempted enemy invasion, would be concerned with the sea and not with the land, and it was important that the Navy be able to deploy air power as well as sea power over the vast ocean areas that it was required to control. The main point of contention between the Army and the Navy air defense policies lay in the Navy claim that land-based bombardment operations were necessary for ranging far over the sea lanes to protect coastal shipping and to attack enemy vessels. Both services were highly mobile and if provided with the proper bases, the Army Air Corps considered itself immediately capable upon the outbreak of war of undertaking strategic offensive operations over water, despite the Navy belief that this violated Navy responsibilities of coastal defense and disrupted unity of air command.

Although there was an increasing appreciation between Army and Navy air officers of the necessity for close cooperation and coordination between aviation components, the rivalry for air defense control prevented its full expression. The Air Corps realized that the possibility of joint air operations in conjunction with the ground forces

on the continent was somewhat remote and that a joint plan for full utilization of sea power and air power was of far greater importance. But with the Navy strongly emphasizing its superiority in the role of national air defense, Army airmen feared that their service was being subordinated to a peacetime role of interior air police force. Their persistant effort to warn the War Department of the impending deterioration of the Air Corps was motivated, according to the record, by a desire to maintain the rightful position of the service in the air defense picture, and to prevent Navy duplication of land installations and combat aircraft, so that on "M-day" Army aviation would be capable of performing its vital mission of protecting the nation.

With the outbreak of war in Europe the Air Corps attempted to reach a closer accord with the Navy as to their respective air missions in the event of American entry into the conflict. General Arnold, Chief of Air Corps, submitted to the Joint Air Advisory Committee a strategic guide to facilitate this matter. Based on the provision of Army and Navy joint action as prepared by the Joint Board, it contained the following missions, in the order of their priority:

(1) Deny establishment of hostile air bases in the Western Hemisphere.

(2) Defeat hostile air forces that may be established in the Western Hemisphere by air action against their base establishments.

(3) Oppose the operations of hostile air forces by fighting in the air.

(4) Operate against hostile expeditionary forces threatening landing on our shores by destroying troop transports and supply ships.

(5) Operate in close cooperation with the other arms of the mobile Army in the conduct of land operations.

Although the Navy members of the Committee agreed to the above provisions in a subsequent meeting, they later repudiated the agreement disclaiming any prior knowledge of the subject, despite the evidence recorded in the minutes of the meeting. This repudiation was brought to the attention of the War Plans Division. The Chief of Air Corps contended that in order to avoid further duplication of effort the Navy should reconsider and accept the repudiated agreement to provide smooth and efficient performance of national defense operations. It was not, however, mandatory that the Navy acknowledge acceptance of the principles as outlined since they simply indicated the methods the Army intended to follow in carrying out its duties and responsibilities toward accomplishment of its mission. General Arnold further suggested a "showdown" with the Navy to clear up the situation but advocated if the decision should be unfavorable that the accepted principles of Air Corps employment, which had been approved by the Chief of Staff, be adopted and pursued.[23]

In the ensuing months of 1940 and 1941, each branch of the service concentrated upon maximum development of their air components and engaged in joint training exercises and maneuvers within the limits of their relative functions.[24] Although little conflict in policies pertaining to dual responsibilities in national defense was evident, there existed an undercurrent of friction and criticism at various levels of command. Thus, in connection with the performance of sea coast reconnaissance Army Commanders were advised that in order to prevent infringement upon the Navy responsibility for conducting "off-shore

patrol" the missions performed by Air Corps airplanes should be referred to as "tactical reconnaissance." Concerning the proposed drafts of preparations for joint operations in the Far East, Hawaii, and Alaska,[25] Lt. Col. H. L. George felt that it over-emphasized Navy operations at the expense of the Army mission. Further, he stated, that[26]

> the augmentation of the Army Air Forces is assumed (per the draft) to be important in making increased air strength potentially available to support naval operations, and in strengthening the power of the fleet for offensive operations . . . . The proposed draft therefor /sic/, gives the Army and Navy commanders concerned an incorrect picture, in that it presents but a part and not the whole.

Pointing to the "lessons of Norway, the action of the British fleet (as such) in the evacuation of Dunkerque, the impotence of the British Mediterranean Fleet at Crete," Colonel George went on to charge that the Navy would make every effort to gain control of land-based bombardment, and that every concession made to the Navy in subordinating the AAF to its control, would strengthen naval claims to control of air force operations and coast defense.[27] In an attempt to provide more amicable relations between the two services Brig. Gen. Carl Spaatz on 7 November 1941 sent a list of instructions to the Commanding General of the Air Force Combat Command for his guidance in fulfilling the Navy Western Defense Plan No. 5. The Commanders of Army Air Forces engaged in the North Atlantic and southern coastal frontiers were to "confer with and prepare plans in cooperation with the appropriate naval commander . . .," and to "participate in such cooperative and supportive operations as are essential to affording the Navy real assistance in performance of the latter's assigned tasks in the actual or suspected presence of German or Italian Forces."[28] Both services gradually recognized that it was

essential for air units of the Army to perform air reconnaissance over the sea in the interest of combat efficiency. In this connection, the Joint Board had prescribed that no restrictions be imposed upon the complete freedom of the Army or Navy to utilize against an enemy the full power of all available aircraft and any and all facilities that might be necessary to make that power effective.[29]

On the eve of the Japanese attack on Pearl Harbor the Commanding General of the Air Force Combat Command was delegated complete responsibility for the preparation and execution of air plans for the defense of the continental United States. This included authority for "purely Air Force plans," combined operations of air and greund forces, and "joint air support plans prepared by Commanders, Naval Coastal Frontiers and the Commanding Generals of appropriate Air Forces."[30] Immediately after the attack General Spaatz directed that action be taken immediately to place Army, Navy, and Marine Corps Aviation based in the continental United States under one commander.[31] Yet, with the subsequent removal of Army and Navy Commanders at Pearl Harbor the controversy flared anew, and to such an extent that Secretary of War Henry L. Stimson sent out a personal order to all commands of the Army in an effort to prevent irresponsible criticism and unfavorable comments regarding actions taken by officers of either branch. Stimson stated that such conduct by Army officers would not be tolerated, since "cooperation and coordination between the two services can only be obtained by mutual respect for each other and each other's efforts. All cooperation with the Navy should be carried out wherever necessary, freely, willingly, and completely. We are all in the war together and have but one

purpose--the winning of the war."[32]

In the months after Pearl Harbor, the Army and Navy were primarily concerned with building up their respective combat but this activity, too, led to further clashes. The Navy requested transfer of approximately two hundred B-24's and nine hundred B-25's and B-26's to their air arm, a move which Col. H. L. George described as "suicidal to our own air program" considering the paucity of these planes for the Army's own use.[33] Again the next month the Navy requested delivery of some four hundred B-24's and nine hundred B-25's, then scheduled for the Army Air Forces, to the U.S. Fleet. A lengthy correspondence ensued between General Arnold and Admiral King in which the various Army and Navy interpretations of the Act of June 5, 1920 were reinvoked.[34] No decision could be reached, however, and instead of furthering the mutual war effort the discussion was in effect accomplishing no more than a revival of old differences between the two services. General Marshall took cognizance of this fact and on 2 April 1942 proposed to Admiral King the following working agreement:[35]

> Army heavy bombardment forces in Hawaii will be increased two full groups . . . . One of these groups will be attached to the Pacific Fleet on a permanent basis for the emergency, unless sooner released by the Navy
>
> . . . . . .
>
> Army bombardment units will be supplied to Naval forces in accordance with agreements for unity of command or operational control. Other suitably located, Army bombardment units will continue to operate in support of, or in lieu of, Naval forces.

Despite this proposal by General Marshall, the controversy continued and rumors abounded. Lt. Gen. Davenport Johnson, Commanding the Caribbean Defense Command, in October 1942 mentioned these rumors (that a large part of AAF equipment, mainly long-range bombers, was to be turned over to the Navy for its operations) to General Arnold. Johnson deplored

this possibility, pointing out that the nation could not afford to support two air forces. He indicated that the development of air power should be consolidated under one head who should be on an equal status with the Army and Navy Chiefs. The events of the war up to that time had convinced him more than ever of the necessity of such a set-up, since "even a country as rich as ours cannot afford a dispersal of air effort."[36] General Arnold admitted that the rumors regarding the Navy's attempt to acquire AAF long-range bombers were "unfortunately true" and that the Navy had been in a measure successful. He reiterated a former opinion that the splitting of the air forces would result in their being relegated to a subordinate or supporting role. The air lessons of the war, he declared, were plain and unmistakable; the struggle to build up the Army Air Forces so that the goal of mass employment could be successfully achieved would continue to be the main objective. Arnold stated that "we are battling to attain it in the face of many odds, including continued and persistent demands from the Navy for diversion of land-based aircraft."[37]

In 1943 the problem of the allocation of heavy bombers to the Navy took a turn for the better, the main reason being increased production and the consequent increasing satisfaction on the part of the Army with the progress of their own expansion program.[38] Indeed in December 1943 the Navy's estimated needs for airplanes through 1945 included no increases in heavy land-based bombers and a decrease in medium bombers.[39]

By the middle of 1944 with the war at its height in all theaters service differences rapidly became submerged in the larger tasks at

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at hand. In a memorandum from Col. L. M. Guyer in the Pacific theater for example increased coordination and cooperation are finally a reality. Citing the Carrier Task Force strikes against the Palaus Islands and Truk, Colonel Guyer stated that "Navy operational plans . . . called for close coordination with AAF operations. This coordination was readily accomplished."[40] And, as an example of unified command and close collaboration of Air and Naval Forces, General Kuter pointed to Admiral Halsey's command in the South Pacific Zone, which consisted of "American naval, marine, and land forces, each with its own separate air service." In the composition of his headquarters, "the Commander was an Air Corps General . . ., his Chief of Staff was a Captain of the Naval Air Service, and his Senior Operations Officer a Colonel of the Marine Air Force. This principle of intermeshing the various services was observed throughout the chain of command and responsibility, and under this unified command the operational units were rapidly losing the consciousness of their original Service differences."[41]

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Appendix B

BOMBER CHART

Symbols

(1) Maximum Range (Normal Bomb Load)
(2) Radius of Action (Approximate)
(3) Operating Altitude
(4) Service Ceiling
(5) High Speed at Operating Altitude
(6) Cruising Speed at Operating Altitude with Normal Bomb Load
(7) Maximum Bomb Load
(8) Normal Bomb Load
(9) Armament
(10) Armor
(11) Normal Crew
(12) Dimensions and Gross Weight (War Maximum)
(13) General Description of Airplane

Date 1918

A. Martin MB-2 — 2 engines — 400 hp each

1. 600 mi.
2. 380 mi.
3. 7,700 ft.
4. 13,000 ft.
5. 98.5 mph
6. 85 mph
7. 1,500 lb.
8. 1,000 lb.
9. 3 x .30 cal.
10. None
11. 3
12. Span -71' 0"
Length-44' 0"
Height-14' 0"
Weight-12,075 lb.

13. Biplane construction; fabric covered wings and fuselage; fixed four wheel landing gear and tail skid; twin rudders; gun installation in nose and rear cockpit with a tunnel gun under fuselage operating from rear cockpit; external bomb racks.

Date 1921

B. Barling NBL-1 — 6 engines — 520 hp each

1. 335 mi.
2. 251 mi.
3. 4,000 ft.
4. 10,000 ft.
5. 93 mph
6. 61 mph
7. 8,000 lb.
8. 5,000 lb.
9. 7 x .30 cal.
10. None
11. 11
12. Span -120' 0"
Length- 65' 0"
Height- 27' 9"
Weight- 41,000 lb.

13. Triplane (or 2-1/2 plane) with wings of wood and fabric construction; fuselage built in sections and of semi-monocoque type, strengthened by longerons, bulkheads, and veneer; landing gear consisted of two "trucks," each of which had dual wheels on front and rear axles; semi-retractable nose wheels; four vertical rudders and fins, the latter forming the interplane struts of the stabilizers; guns operated from five cockpits located in front, sides, and rear, with tunnel guns in bottom, front, and rear; external bomb racks.

Date 1930

C. Keystone B-3A — 2 engines — 520 hp each

1. 510 mi.
2. 382 mi.
3. 5,000 ft.
4. 12,700 ft.
5. 102 mph
6. 76 mph
7. 2,496 lb.
8. 1,995 lb.
9. 3 x .30 cal.
10. None
11. 5
12. Span - 74' 8"
    Length - 48' 10"
    Height - 15' 9"
    Weight - 12,749 lb.

13. Biplane construction; fabric covered wings and fuselage; single rudder; two wheel fixed landing gear and tail wheel; guns in nose, rear cockpit, and in tunnel arrangement beneath fuselage; external bomb racks.

Date 1932 (B-10-B 1935)

D. Martin B-10 — 2 engines — 675 hp each

1. 507 mi.
2. 380 mi.
3. 4,500 ft.
4. 21,000 ft.
5. 207 mph
6. 178 mph
7. 4,380 lb.
8. 2,260 lb.
9. 3 x .30 cal.
10. None
11. 4
12. Span - 70' 6"
    Length - 45' 3"
    Height - 11' 0"
    Weight - 13,357 lb.

13. Midwing monoplane of all metal construction; monocoque fuselage with corrugated top and bottom surfaces, smooth skin interior; smooth skin wing with metal surfaces to rear spars; fabric covered trailing edge, elevator, and rudder; gun turret in front cockpit; bombs carried internally; retractable landing gear and tail wheel.

Date 1935

E. Boeing XB-17 — 4 engines — 850 hp each

1. 2,260 mi.
2. 700 mi.
3. 14,000 ft.
4. 30,600 ft.
5. 256 mph
6. 228 mph
7. 4,000 lb.
8. 2,500 lb.
9. 5 x .50 cal.
10. None
11. 6
12. Span - 103' 9"
Length - 68' 4"
Height - 18' 3"
Weight - 34,833 lb.

13. All metal midwing monoplane with aluminum alloy stressed skin; semi-monocoque fuselage consisting of longitudinal and circumferential stiffeners, bulkheads, and smooth metal outside skin; retractable landing gear and tail wheel; air brakes on wheels; wing flaps and control tabs; flexible guns installed in nose, one above and below the fuselage, and in streamlined "blisters" on sides of fuselage, all manually operated.

F. Date 1943

Boeing B-17G — 4 engines — 1200 hp each

1. 3,630 mi.
2. 2,702 mi.
3. 25,000 ft.
4. 35,000 ft.
5. 295 mph
6. 250 mph
7. 6,000 lb.
8. 2,500 lb.
9. 13 x .50 cal.
10. Flak curtains for crew
11. 9
12. Span - 103' 9"
Length - 68' 4"
Height - 19' 1"
Weight - 56,000 lb.

13. Similar to XB-17, except that armament has been modified to a chin turret, top turret, ball turret, rear turret, power operated; redesigned empennage surfaces; new type engine turbo superchargers; deicing system; oxygen equipment; wing fuel tanks; self-sealing fuel tanks; external bomb rack available; complete radio and navigation equipment; life raft.

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Date 1938

G. Boeing B-15 — 4 engines — 1000 hp each

1. 3,800 mi.
2. 2,950 mi.
3. 6,000 ft.
4. 18,500 ft.
5. 200 mph
6. 145 mph
7. 12,000 lb.
8. 2,500 lb.
9. 6 x .30 cal. or .50 cal.
10. None
11. 10
12. Span -149' 0"
    Length - 87' 11"
    Height - 18' 5"
    Weight - 70,000 lbs. (approx.)

13. All metal, midwing monoplane; retractable dual-wheeled landing gear; wheel air brakes; wing flaps and control tabs; heating and ventilating system; deicing installation; fire protection apparatus; automatic pilot; sleeping and living accomodations for normal crew; radio direction finding equipment; machine gun stations in nose turret, top turret, and in four streamlined "blisters" on side and bottom of fuselage.

Date 1940

H. Consolidated XB-24 — 4 engines — 1200 hp each

1. 3,000 mi.
2. 2,250 mi.
3. 15,000 ft.
4. 31,500 ft.
5. 310 mph
6. 230 mph
7. 8,960 lb.
8. 2,500 lb.
9. 7 x .50 cal.
10. None
11. 6 to 8
12. Span -110' 0"
    Length - 67' 2"
    Height - 17' 11"
    Weight - 56,000 lb.

13. All metal, high-wing, cantilever type, monoplane; wing in three sections and of new airfoil design, having straight taper and high aspect ratio; fuselage of aluminum alloy, monocoque design, with flush riveted skin; twin rudders and fins; retractable tricycle landing gear; three-bladed, full-feathering hydromatic propellers; hydraulically operated wing flaps, brakes, and bomb bay doors; guns located in nose, in turrets on top and bottom of the fuselage, and in the tail.

Date 1944

I. Consolidated B-24J — 4 engines — 1200 hp each

1. 3,614 mi.
2. 2,810 mi.
3. 25,000 ft.
4. 28,000 ft.
5. 297 mph
6. 177 mph
7. 12,800 lb.
8. 2,500 lb.
9. 10 x .50 cal.
10. Flak curtains for crew
11. 8
12. Span - 110' 0"
    Length - 67' 2"
    Height - 17' 11"
    Weight - 64,000 lb.

13. Similar to XB-24 except that this model has new type turbo supercharger; complete radio system and navigation equipment; automatic pilot; new nose turret, power operated; improved fire power; double bomb bay doors.

Date 1939

J. Douglas XB-19 — 4 engines — 2,000 hp each

1. 5,200 mi.
2. 3,900 mi.
3. 15,700 ft.
4. 25,000 ft.
5. 204 mph
6. 160 mph
7. 36,000 lb.
8. 2,400 lb.
9. 6 x .30 cal., 5 x .50 cal., 2 x 37 mm. cannon
10. None
11. 10
12. Span - 212' 0"
    Length - 132' 0"
    Height - 42' 0"
    Weight - 160,000 lb.

13. All metal, low-wing monoplane with swept back leading edge and training edge wing; single fin and rudder; retractable tricycle landing gear; power driven turrets in nose, upper front and rear, lower front and rear; tail gun manually operated; sleeping and living quarters for normal crew; geared engine supercharger; constant speed, full feathering propellers; wing flaps and control tabs; automatic pilot; radio and navigation equipment.

Date 1943

K. Boeing YB-29 — 4 engines — 2,000 hp each

1. 4,524 mi.
2. 3,393 mi.
3. 25,000 ft.
4. 32,100 ft.
5. 368 mph
6. 250 mph
7. 16,000 lb.
8. 2,000 lb.
9. 10 x .50 cal., 1 x 20 mm. cannon
10. Pilot, bombardier, and fire control operators.
11. 12
12. Span - 143' 3"
    Length - 99' 0"
    Height - 27' 9"
    Weight - 105,000 lb.

13. All metal, midwing monoplane with aluminum alloy stressed skin; retractable tricycle landing gear; pressure cabin installation; engine turbo supercharger; hydraulic brakes; wing flaps and control tabs; three bladed, full feathering, constant speed propellers; guns located in remotely controlled turrets in upper front and rear, lower front and rear; cannon in tail turret.

Date 1944

L. Boeing B-29 — 4 engines — 2,200 hp each

1. 4,400 mi.
2. 3,300 mi.
3. 30,000 ft.
4. 38,000 ft.
5. 361 mph
6. 270 mph
7. 20,000 lb.
8. 4,000 lb.
9. 10 x .50 cal., 1 x 20 mm. cannon
10. Pilot, bombardier, and fire control operators.
11. 10
12. Span - 143' 0"
    Length - 99' 0"
    Height - 27' 9"
    Weight - 135,000 lb.

13. Similar to YB-29 except for following modifications: three pressurized compartments (fore, aft, and stern); central fire control system with sighting stations in nose, tail, top, and on both sides; turrets in upper front and rear, lower front and rear, and tail; complete radio and navigating equipment; special design, full span flaps; improved bomb bay doors; four-bladed full feathering, constant speed hydromatic propellers; engine-driven electrical system; self-sealing fuel tanks.

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Date 1944

M. Consolidated B-32 — 4 engines — 2,200 hp each

1. 5,625 mi.
2. 3,218 mi.
3. 25,000 ft.
4. 30,700 ft.
5. 360 mph
6. 270 mph
7. 20,000 lb.
8. 5,625 lb.
9. 10 x .50 cal.
10. Pilot, bombardier, and fire control operators
11. 8
12. Span - 135' 0"
    Length - 82' 11"
    Height - 28' 0" (Tread height is 33' 0")
    Weight - 123,250 lb.

13. High-wing, single tail, all metal semi-monocoque construction; cabin supercharging installation; turbo superchargers; guns installed in nose turret, front top turret, rear top turret, lower ball turret, and tail turret, all remotely controlled from computer stations; retractable tricycle landing tear; radio aquipment; automatic pilot; self-sealing fuel tanks; wing flaps and control tabs.

Date 1945

N. Northrup XB-35 — 4 engines — 3,000 hp each

1. 5,200 mi. (est.)
2. 3,900 mi. (est.)
3. 35,000 ft.
4. 40,000 ft.
5. 386 mph (est.)
6. 290 mph
7. 32,000 lb.
8. 10,000 lb.
9. 8 x .50 cal.,
   2 x 37 mm. cannon
10. Fuel (60%), crew, and engines
11. 8
12. Span - 172' 0"
    Length - 53' 0"
    Height - 19' 3"
    Weight - 161,640 lb.

13. All metal, flying wing (tailless); submerged engines driving dual rotation propellers through long drive shafts; retractable tricycle landing gear (dual main wheels, single nose wheel); pressurized crew compartment; dual turbo-superchargers; four eight-bladed propellers, full feathering, constant speed; central fire control system with sighting stations upper and lower wing, nose, and tail; turrets in upper wing, lower wing, tail, all guns flexible and remotely controlled from sighting stations; complete radio and navigation equipmont; automatic pilot.

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Date 1945

0. Consolidated XB-36 — 6 engines (pusher) — 3,000 hp each

1. 10,000 mi.
2. 7,500 mi.
3. 30,000 ft.
4. 40,000 ft.
5. 372 mph (est.)
6. 279 mph (est.)
7. 72,000 lb. (for 4,790 mi.)
8. 10,000 lb.
9. 8 x .50 cal., 6 x 37 mm. cannon
10. Crew and engines
11. 9
12. Span - 230' 0"
    Length - 163' 0"
    Height - 43' 11"
    Weight - 269,039 lb.

13. All metal, high wing, single tail, pusher type monoplane; retractable tricycle landing gear; pressure cabin; self-sealing fuel and oil system; remotely controlled power operated guns; forward upper and lower fuselage turrets, locally operated and pressurized; aft fuselage turrets and tail turret; complete radio and navigation equipment; automatic pilot; dual turbo superchargers; instrument landing devices.

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GLOSSARY

AAC	Army Air Corps
AAFPGC	Army Air Forces Proving Ground Command (AFPGC)
AAG	Central Files of the AAFHQ, formerly under jurisdiction of the Air Adjutant General.
AC/AC	Assistant Chief of Air Corps
AC/AS	Assistant Chief of Air Service; Assistant Chief of Air Staff
ACB	Air Corps Board
AC/MD	Assistant Chief of Materiel Division
AC/S	Assistant Chief of Staff
AC/SD	Assistant Chief of Supply Division
ACTS	Air Corps Tactical School
AD/AS	Assistant Director of Air Service
ADC	Air Defense Command
AEF	American Expeditionary Forces
AFAMC	Air Force Air Materiel Command
AFCC	Air Force Combat Command
AFDMR	Air Force Directorate of Military Requirements
AFHD	Air Force Historical Division
AFRDB	Air Force Requirements, Directorate of Bombardment
AFSAT	Air Forces School of Applied Tactics
AG	Adjutant General
APGC	Air Proving Ground Command
AS	Air Staff
ASC	Air Service Command
AS/W	Assistant Secretary of War
ATS	Air Technical Section
ATSC	Air Technical Service Command
AWPD	Air War Plans Division
C/AAF	Chief of the Army Air Forces
C/AC	Chief of the Air Corps
C/AS	Chief of Air Service; Chief of Air Staff
CDC	Caribbean Defense Command
C/ED	Chief, Engineering Division
C/EES	Chief, Experimental Engineering Section
CG	Commanding General
CG/SS	Commanding General, Staff School
C/ID	Chief, Information Division
CinC	Commander-in-Chief
CINCPOA	Commander-in-Chief, Pacific Ocean Area
C/MD	Chief, Materiel Division
CNO	Chief of Naval Operations
CPA	Central Pacific Area
C/PD	Chief, Plans Division
C/PS	Chief, Plans Section
C/RD	Chief, Requirements Division

C/S	Chief of Staff
C/SD	Chief, Supply Division
CS/GHQAF	Chief of Staff, General Headquarters Air Force
CWTD	Cold Weather Testing Detachment
DAC/AS	Deputy Assistant Chief of Air Staff
DC/NO	Deputy Chief of Naval Operations
DC/S	Deputy Chief of Staff
DG/OPM	Director General of Office of Production Management
DMA	Division of Military Requirements, AEF
ED	Engineering Division
EES	Experimental Engineering Section
FAC	Federal Aviation Commission
FY	Fiscal Year
GHQAF	General Headquarters Air Force
GSC	General Staff Corps
HB	Heavy Bomber; Heavy Bombardment
HS	Historical Section
JAAC	Joint Air Advisory Committee
JAG	Judge Advocate General
JB	Joint Board
MC	Materiel Command
MC/ED	Materiel Command, Engineering Division
MD	Materiel Division
MM&D	Materiel, Maintenance and Distribution
NAA	National Aeronautic Association
OAC/AS	Office of Assistant Chief of Air Staff
OAS/W	Office of Assistant Secretary of War
OC/AC	Office of Chief of Air Corps
OC&R	Operations, Commitments and Requirements
OMC	Office of Management Control
OS/W	Office of Secretary of War
PD	Proof Division; Plans Division
S/AS	Secretary of Air Staff
S/N	Secretary of Navy
S/W	Secretary of War
UK	United Kingdom
USAFFE	United States Air Forces in the Far East
USSAF	United States Strategic Air Force
VHB	Very Heavy Bomber; Very Heavy Bombardment

WD	War Department
WF	Wright Field
WPD	War Plans Division

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37. Memo for AC/AS, MM&D, from C/RD, AC/AS, OC&R, 25 Apr. 1944, in AAG 452.02B Military Characteristics of Aircraft. These requirements and principle characteristics were declared to supersede those dated 12 Oct. 1939 for heavy bombardment airplanes.

38. Interview by Maj. F.D. Walker, AC/HS, ATSC, with Maj. G.W. Hard, ATSC Liaison Officer to B-29 Committee, 10 May 1945, in AAFATSC History of the Supply, Maintenance and Training for the B-29.

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2. R&R (R&R, C/AC to C/MD, 18 July 1941), MD to T&O Div., 21 July 1941, in AAG 385 Misc. B.

3. Memo for C/AS from Maj. H.S. Hawsell, 26 Nov. 1941, in AAG 337, Conferences.

4. Ibid.

5. Memo for Brig. Gen. J. McNarney, GSC, from Maj. C.A. Brandt and Maj. B. Walsh, 24 July 1941, in AAG 385 Misc. B.

6. Speech at West Point Military Academy, 21 Dec. 1942, in AAG 350.001A, Addresses, Lectures, and Speeches.

7. Ltr., CG/8th AF to C/AS, 2 Jan. 1943, in AAG 312.1A, Operations Letters.

8. Memo for CG/AAF from Comdt/AFSAT, 16 Aug. 1943, in AAG 353.41C, Aerial Bombing and Gunnery.

9. R&R, Brig. Gen. E.L. Eubank, AFRDB, to Col. R.W. Harper, GSC, 26 Oct. 1942, in AAG 452.1E.

10. AFDMR Diary, 18 Sept. 1942, in AAG 319.1-3.

11. Air Historical Study, No. 18, Development of Tactics in the AAF (30 May 1944).

12. Ibid., pp. 46-9.

13. For a thorough study of this activity see Air Historical Study, No. 16, Modification of Army Aircraft in the United States, 1939-1945 (Aug. 1947).

14. Memo on Fighter Tactics of GAF during Schweinfurt Raid, 14 Oct. 1943, in AAG 373.1A, Tactics and Technique.

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15. Memo for OC&R, Bomb. Br., from ORS, Hq. 8th AF, 25 Dec. 1943, in B-17 Modifications file, OC&R, BB.

16. Memo for CG/8th AF from AC/AS, OC&R, 2 June 1944, in AAG 452.1L.

17. Memo for WF from AC/AS, MM&D, 20 May 1944, in MM&D Daily Diary.

18. Memo for CG/AAF by Director, ATS, USSAF, 30 June 1944, in AAG 452.1M.

19. Memo for AS/W from AC/AS, MM&D, 4 July 1944, in AAG 452.1M.

20. Memo for CG/8th AF from AC/AS, OC&R, 2 June 1944, in AAG 452.1L.

21. R&R, AFAMC to AFDMR, 11 Sept. 1942, in AAG 452.B, Modifications.

22. AAG 385B, Warfare, passim.; memo for CG/5th Wing, MTO, from CG/97th Bomb. Gp., 2 Oct. 1943, in AAG 373.1, Tactics.

23. Memo for CG/MC from AFDMR, 1 Feb. 1943, in AAG 452.02A, Modification.

24. Air Historical Study, No. 62, Modification of Army Aircraft in the United States, 1939-1945 (Aug. 1947), p. 26.

25. Memo for CO/CWTD from CO/"C" Flight, 16 Jan. 1943, in AAG 452.02A.

26. Memo for CINCPOA from CG/CPA, 6 Dec. 1943, in AAG 385B, Warfare.

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2. Statistical Control Division, MC, Aircraft Acceptances and Deliveries, Oct. 1943.

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1. Memo for AS/W from Maj. Gen. M.M. Patrick, C/AC, 9 Sept. 1927, in AAG 111.3, Duplication of Effort between the Army and Navy /hereinafter referred to as Duplication/.

2. Ibid.

3. Naval Appropriation Act for the Fiscal Year Ending June 30, 1921, 66 Cong., 1 Sess., 133 (11 July 1919), H.R. 5608, Pub. No. 8.

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7. Maj. T. DeWitt Milling, "Air Power in National Defense" (unpublished study, 1924), p. 14.

8. Report of the Select Committee of Inquiry into the Operations of the United States Air Services, 68 Cong., 2 Sess., Rept. No. 1653 (14 Dec. 1925).

9. Memo for AS/W from C/AC, 9 Sept. 1927, in AAG 111.3 (Proposed amendment to JB 349, Serial 273, para. 2).

10. Aeronautical Board discussion of Air Defense Policies, 22 Nov. 1926, pp. 2-14, in AAG 323.5 (Special), Army and Navy Controversy.

11. Memo for JAG from Capt. Ira C. Eaker, Exec., 12 Oct. 1927, in AAG 323.5 (Special).

12. Memo for AS/W from AC/AC, 5 Nov. 1927, in AAG 323.5 (Special).

13. Untitled Study, author unknown, n.d. (approx. 1934).

14. S/W to President, 22 Aug. 1930, in AAG 323.5 (Special).

15. Memo for C/S from Brig. Gen. C.E. Kilbourne, 27 Oct. 1932, in AAG 370.3.

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16. WD Press Release, 9 Jan. 1931.

17. Annual Rept. of C/S, in Report of the Secretary of War to the President, 1931, p. 38.

18. Memo for C/S from AC/AC, 1 May 1934, in AAG 400.12, Army and Navy Procurement. No evidence of any action taken has been found. Admiral E. J. King, successor to Admiral Pratt, when assuming office had repudiated the "paper" agreement on air defense (see memo for DC/S from Lt. Col. S.E. Fickel, 30 Jan. 1934, in AAG. 210.7, Misc., Comd.).

19. Memo for DC/S from Lt. Col. J.E. Fickel, 30 Jan. 1934.

20. WD statement for FAC, 31 Aug. 1934; Navy Dept. statement for FAC, Nov. 1934.

21. This was considered typical of the Navy attitude toward the air defense system since 1921, the Chief of the Air Corps observed, in memo for C/SC from C/AC, 8 May 1936, in AAG 045.4, Navy Dept.

22. Memo for C/AC from C/PS, 19 Jan. 1939.

23. Memo for WPD from C/AC, 5 Oct. 1940, in AAG 370.3D, Coast Defense.

24. AAG 353D, Joint Training, passim.

25. Draft, from CNO and C/S to CinC, U.S. Asiatic Fleet and CG/USAFFE, 14 Oct. 1941, in AFHD file 145.96-146.

26. Memo for C/AS from AC/AS, AWPD, 21 Oct. 1941, in 145.96-146.

27. Ibid.

28. C/AC (for C/AAF) to CG/AFCC, 7 Nov. 1941, in 145.96-146.

29. Memo for C/S from S/AS, 13 Oct. 1941, in AAG 370.D, Coast Defense. See also JB 349, Serial 539.

30. Memo, unsigned, for CG/AFCC, 5 Dec. 1941, in 145.96-146.

31. Memo for Col. H.L. George from Col. K.N. Walker, 9 Dec. 1941, in 145.96-146.

32. Memo for all Army Commands from S/W, 20 Dec. 1941, in AAG 045., Misc., Navy Dept.

33. Memo for Gen. Arnold from AC/AS, AWPD, 15 Jan. 1942, in 145.96-146.

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34. Memo for C/AAF from CinC/U.S. Fleet, 20 Feb. 1942; ltr., Lt. Gen. H.H.Arnold to CinC/U.S. Fleet, 25 Feb. 1942; memo for C/S from Lt. Gen. H.H. Arnold, 25 Feb. 1942; ltr., CinC/U.S. Fleet to Lt. Gen. H.H. Arnold, 5 Mar. 1942; ltr., CG/AAF to CinC/U.S. Fleet, 9 Mar. 1942.

35. Ltr., C/S to CinC/U.S. Fleet, 2 Apr. 1942.

36. Ltr., CG/CDC to CG/AAF, 23 Sept. 1942, in AAG 312.1F, Ops. Ltrs.

37. Ltr., CG/AAF to CG/CDC, 26 Oct. 1942, in AAG 312.1F.

38. Memo for Gen. Meyers from Acting AC/AS, Plans, 30 June 1943.

39. Memo for Gen. Arnold from DC/NO (Air), sub.: Aircraft Prog. U.S. Navy, 28 Dec. 1943.

40. Memo for Gen. Hansell thru Col. Loutzenheiser from Col. L.M. Guyer, C/AC, Pacific Section, 5 May 1944, Tab B-3.

41. Ibid., Tab D.

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